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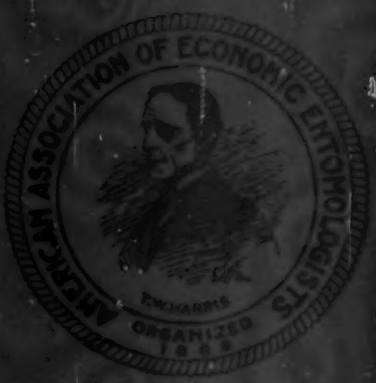
Vol. 27 DECEMBER, 1934 No. 6

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists



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Published by
American Association of Economic Entomologists
Geneva, N. Y.

Entered March 14, 1921 as second-class matter at the Post-Office at Geneva, N. Y., under the Act of Congress of March 3, 1879.

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Forty-Seventh Annual Meeting of the

American Association of Economic Entomologists

Pittsburgh, Pa.

December 27 to 29th, 1934

FORTY-SEVENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, PITTSBURGH, PA.

December 27 to 29th, 1934

The 47th Annual Meeting of the American Association of Economic Entomologists will be held at Pittsburgh on the above dates. All sessions will be held in the Hotel William Penn which is also hotel headquarters.

The schedule of meetings has been arranged as follows:

Thursday, December 27.
Section of Plant Quarantine and Inspection, Sessions 10:00 A. M. and 3:30 P. M.
General Session. President's Address. Brief Reports of Entomological Meetings of the Year. Reading of Papers, 2:00 P. M.

Thursday Evening, Meeting of Executive Committee, 8:00 P. M.
Section of Apiculture, Session 7:30 P. M.
Section of Extension, Session 7:30 P. M.
Moving Picture Film, 7:30 P. M.

Friday, December 28. Opening Business Session. Reading of papers, 9:00 A. M.
Afternoon Session, Invitation Papers, 1:30 P. M.

Friday Evening, Entomologists' Smoker.

Saturday, December 29. General Session, 9:30 A. M.
Afternoon Session, Symposium on International Problems in Entomology.
Final Business Session, 1:30 P. M.

OTHER MEETINGS

The Annual Meeting of the American Association for the Advancement of Science, its sections and affiliated societies, will be held December 27, 1934 to January 2, 1935. Important features of their program will be published in Science (first copy in December). Many of these will be of interest to our members.

The Entomological Society of America will open its meeting Thursday morning, December 27, and continue through Friday, December 28. It has arranged a Symposium on "Improved Technique in the Study of Insects" at 9:30 Friday morning and holds a joint session with the Ecological Society of America on Saturday morning.

The annual public address before that society will be delivered by Dr. Clarence H. Kennedy on Friday evening. Members of our Association are cordially invited to attend these sessions.

HOTEL HEADQUARTERS

Hotel headquarters have been secured at the William Penn Hotel. The special convention rates are as follows:

Room, with bath, one person	$3.00, $3.50, $4.00.
Room, with bath, two persons	$5.00, $5.50, $6.00.

RAILROAD RATES

Reduced railway rates on the receipt certificate plan have been granted by almost all railroads in the United States and Canada. Persons attending the meeting should purchase a first-class, one way ticket to Pittsburgh, securing a Receipt Certificate reading "For the American Association for the Advancement of Science and Associated Societies." The certificate must be left at the registration desk to be called for later in the same place. Each person presenting an endorsed and validated certificate may purchase a return ticket for one-third of the regular fare, on the same route as used in going to Pittsburgh. Tickets to Pittsburgh from many points may be purchased between December 24 and December 29, although from far western points they may be purchased as early as December 15. Return tickets must be purchased by January 5, 1935.

Special round-trip railway fares have been announced by the Central and Trunk Line passenger associations. These Associations cover points east of and including Chicago and St. Louis north of the Ohio and Potomac Rivers to the Atlantic Seaboard south of New England and Canada. Tickets will be on sale from December 21 to 25 inclusive, for trains leaving starting points at and after 12 o'clock noon of December 21 to and including 12 o'clock noon of December 25. Final return limit is January 6, 1935. In connection with these round-trip holiday fares, the Pullman Company has authorized reduced rates for round-trip Pullman tickets.

The possibility of further reduction of fares and the various periods when going tickets may be purchased on the certificate plan make it advisable to consult the local ticket agent.

REGISTRATION

The Headquarters of the American Association for the Advancement of Science for registration and validation of certifications will be located in the new Mellon Institute for Industrial Research.

The usual fee of $1.00 will be charged for registration, validation, etc.

ENTOMOLOGISTS' SMOKER

This will replace the customary Entomologists' Dinner, and will be held on Friday evening following the Annual Address before the Entomological Society of America.

MEMBERSHIP

Applications for membership can be secured from the Secretary or from the Committee on Membership. These should be filled out, properly endorsed and filed with the Membership Committee on or before December 28. Each application must be accompanied with a fee of $4.00.

A. A. A. S. MEMBERSHIP

Members of our Association are granted the privilege this year of joining the A. A. A. S. without payment of the customary initiation fee of $5.

Application cards are available through the Permanent Secretary of that Association.

MOVING PICTURE FILMS

Through the kindness of the Bureau of Entomology and Plant Quarantine arrangements have been made to exhibit three new moving picture films on insects. These are entitled (1) The Japanese Beetle—Life History and Damage, (2) The Mosquito (3 reels), (3) The Honey Bee (4 reels). These films will be shown on Thursday Evening at 7:30 in the Urban Ball Room.

PROGRAM

Thursday Morning Session, December 27, 10:00 A. M. Cardinal Room.

Section of Plant Quarantine and Inspection

A. S. Hoyt, *Chairman* S. B. Fracker, *Secretary*

Appointment of Committees on Resolutions and on Nominations.

Address by the Chairman, A. S. Hoyt, Washington, D. C.

1. Possible Future Policies in Plant Quarantine Work. L. A. Strong, Washington, D. C.
2. The Treatment of Imported Spanish Grapes and other Foreign Quarantine Developments during the Year. E. R. Sasscer, Washington, D. C.

3. Field Tests of Chemicals Used in Connection with Eradication of Potato Wart. R. H. Bell, Harrisburg, Pa.

4. Progress in the Suppression of the Dutch Elm Disease in the United States. L. H. Worthley, White Plains, N. Y.

5. Results of the Research Work on the Dutch Elm Disease Fungus During the Year. R. Kent Beattie, Washington, D. C.

6. Use of Labor by Members of CCC for Suppression of Forest Pests and Diseases. H. L. McIntyre, Albany, N. Y.

7. The Wisconsin Reciprocal Nurseryman's License. E. L. Chambers, Madison, Wisconsin.

8. Japanese Beetle Outbreak at St. Louis, and its Control. C. W. Stockwell, Philadelphia, Pa.

Program

Thursday Afternoon Session, December 27, 3:30 P. M. Cardinal Room.

9. The Work of the Mexican Plant Inspection Service. Alf. Dampf, San Jacinto, Mexico.

10. New Treatment for Disinfecting Shipments to be Moved in Commerce. L. A. Hawkins, Washington, D. C.

11. Organization of Grasshopper and Chinch Bug Campaigns During the Past Summer and their Results. P. N. Annand, Washington, D. C.

12. Court Proceedings Affecting Pest Control Legislation. S. B. Fracker, Washington, D. C.

13. Restricting Sales from Infested Parts of Otherwise Healthy Nurseries. W. W. Ellenwood, Columbus, Ohio.

Report of the National Plant Board. W. C. O'Kane, Chairman, Durham, N. H.

Reports of the Regional Boards:

The Eastern Plant Board. E. N. Cory, Secretary, College Park, Md.

The Central Plant Board. P. T. Ulman, Secretary, Indianapolis, Ind.

The Southern Plant Board. J. H. Montgomery, Secretary, Gainesville, Florida.

The Western Plant Quarantine Board. A. C. Fleury, Secretary-Treasurer, Sacramento, Calif.

Report of Resolutions Committee.

Report of Nominating Committee.

Selection of Officers.

Adjournment.

Program

Thursday Afternoon Session, December 27, 2:00 P. M. Urban Ball Room.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Annual Address of the President, E. F. Phillips, Ithaca, N. Y.

1. The Increasing Complexities of Economic Entomology.

Some outstanding features of Entomological Meetings of the year. (5 minute reports.)

Pacific Slope Branch. William Moore, New York City, N. Y.
Cotton States Branch. Oliver I. Snapp, Fort Valley, Ga.
Eastern Branch. L. A. Stearns, Newark, Del.
Entomological Society of Ontario. Arthur Gibson, Ottawa, Canada
Texas Entomological Society. S. W. Bilsing, College Station, Texas
North Central States Entomologists. J. J. Davis, Lafayette, Ind.

Reading of Papers

2. Teaching Economic Entomology. (10 min.) David Dunavan, Clemson College, South Carolina. (Lantern).

Description of some effective methods of teaching Economic Entomology to college students who are specializing in Entomology.

3. Further Studies of Radio Waves Against Insects. (5 min.) Thomas J. Headlee, New Brunswick, N. J. (Lantern).

Studies designed to practicalize the use of radio waves against insects.

4. Experimental Evidence on the Value of Strip Farming as a Natural Control Method of Injurious Insects with Special Reference to Plant Lice. (10 min.) S. Marcovitch, Knoxville, Tenn. (Lantern).

Plots of cantaloupes and peas were destroyed by the melon louse and pea aphid, but when planted at the same date only 120 yards away as strips alternating with cotton, corn, and other plants, the peas and melons were practically free of plant lice. The mixed plantings by providing a variety of host plants with their accompanying plant lice is a means of keeping the parasites and predators at a permanently high level.

5. Technique of Field Experimentation in Entomology. The Reduction of Data by the Method of Analysis of Variance. (5 min.) L. L. Huber and J. P. Sleesman, Wooster, Ohio.

This paper deals essentially with experimental planning and analysis of experimental data.

6. Some Practical Considerations of Field Plot Technique for Entomologists. (10 min.) G. F. MacLeod, Ithaca, N. Y. (Lantern).

Consideration of some of the factors which should be recognized in planning a field experiment in insect control. Illustrated by data from potato spraying and dusting experiments in New York State.

7. An Adaptation of a Photronic Cell for Measuring Small Leaf Areas. (5 min.) J. W. Bulger, Takoma Park, Md. (Lantern).

This paper is a description of how a photronic cell, when placed in the circuit of D'Arsonval wall galvanometer, has been adapted to measuring small leaf areas.

8. A Preliminary Survey of the Insect Fauna of Some Typical Michigan Trout Streams. (10 min.) W. F. Morofsky, East Lansing, Mich. (Lantern).

A quantitive study of the insects found in typical Michigan trout streams by various methods of sampling in representative cover.

9. The Economic Importance of Cynipidae. (5 min.) Alfred C. Kinsey, Bloomington, Ind.

The only economic forms are those that produce galls in the terminal twigs of oaks. The many other species do no appreciable damage; and because of their strictly specific host relationships imported species are likely to become pests.

10. Control Experiments on Certain Species of *Tarsonemus* Mites. (10 min.) Floyd F. Smith, Washington, D. C. (Lantern).

Results of tests on control by heat treatments together with preliminary information on the possibilities of control of *Tarsonemus pallidus*, *T. latus* and associated species, by spraying, dusting and fumigation are given.

11. The Screw Worm Outbreak in the Southeastern States. (5 min.) W. E. Dove and D. C. Parman, Washington, D. C.

In 1933 the screw worm made its first appearance as a pest of livestock in Georgia and Florida. In 1934 the outbreak became wide spread in these states and extended to most of the southeastern states. Losses from death and injury among all classes of livestock were heavy. Responding to urgent appeals from citizens and state authorities, the Bureau of Entomology and Plant Quarantine inaugurated an intensive educational and control campaign in cooperation with the Federal Emergency Relief Administration and other Federal, state and local agencies. The Bureau directed the operations and the F. E. R. A. allotted funds for chemicals and labor.

To Be Read By Title

12. Mosquito-Control Activities in the Pacific Northwest Under the CWA Program. H. H. Stage, Portland, Oregon.

Three more or less different types of work were conducted in the control of three associations of mosquito species in Oregon and Washington under the CWA program from December, 1933 to April, 1934. A brief account is given of the extent of ground treated as well as the expense.

13. A Biometrical Comparison of the Productivity, Longevity and Developmental Period of Two Morphologically Similar Species of *Trichogramma*. M. F. Bowen, Twin Falls, Idaho.

14. A Summary of the Pest Mosquito Control Work in Louisiana in 1934. W. E. Anderson and H. L. Dozier, Baton Rouge, La.

15. Observations on Breeding Places and Winter Activities of Mosquitoes in Vicinity of New Orleans, La. H. L. Dozier, Baton Rouge, La.

16. Handling Mosquitoes on Equine Encephalomyelitis Investigations. G. F. Knowlton and J. A. Rowe, Logan, Utah.

This report deals with equipment and methods used in handling and feeding mosquitoes on insect transmission of equine encephalomyelitis studies conducted at the Utah Agricultural Experiment Station.

Reading of Papers

Section B, Silver Room

Vice President F. C. BISHOPP in charge.

THE CODLING MOTH AND ITS CONTROL

17. The Value of Supplementary Methods of Control for Codling Moth. (10 min.) J. J. Davis, Lafayette, Indiana.

18. Some Further Observations on the Influence of Artificial Light upon Codling Moth Infestation. (10 min.) P. J. Parrott and Donald L. Collins, Geneva, N. Y. (Lantern).

Data from trap catches, caterpillar counts, and fruit examinations in an apple orchard equipped with light traps. Remarks on the significance of the various types of data.

19. Comments upon Phototropism in the Codling Moth with Reference to the (Anatomy and) Physiology of the Compound Eye. (10 min.) Donald L. Collins and William M. U. Machado, Geneva, N. Y. (Lantern).

Attention is called to certain aspects of the anatomy and physiology of the compound eyes which have a definite bearing upon the responses of the codling moth to light.

20. Varietal Susceptibility to Codling Moth Injury. (5 min.) C. R. Cutright and H. E. Morrison, Wooster, Ohio. (Lantern).

A summary of varietal differences to codling moth injury as noted over a period of years. Specific figures are given.

21. *Ascogaster carpocapsae* in relation to Spray Practices. (5 min.) James A. Cox, Geneva, N. Y. (Lantern).

Field and laboratory work on *Ascogaster carpocapsae* in relation to arsenical sprays for the Codling Moth.

22. Increasing Arsenic Deposit to Control the Codling Moth. (10 min.) James Marshall and R. L. Webster, Pullman, Washington. (Lantern).

The use of oleic acid, especially with fish oil, with lead arsenate to build up high deposit of arsenic on apples and to combat heaviest infestations of the codling moth.

23. Toxicity of Cuprous Cyanide Sprays to Codling Moth (*Carpocapsa pomonella* L.) on Apple. (5 min.) E. R. McGovran, Urbana, Ill. (Lantern).

Laboratory and orchard tests show that cuprous cyanide approximately equals lead arsenate in toxicity to codling moth. However, the experimental material used in 1934 which contained 86% cuprous cyanide produced marked injury in the orchard.

24. 1934 Experiments with Newly Developed Types of Oil Sprays for Codling Moth Control. (5 min.) C. R. Cleveland, Chicago, Ill.

Comprehensive findings from two large orchard field tests as to practicability and methods of handling and mixing; influence on spray coverage and deposit; comparative effects on foliage and on color and finish of fruit; influence on lead and arsenic loads and on residue removal; and control results obtained from various combinations and schedules, alone, with nicotine and with arsenate of lead, are discussed.

25. The Insecticidal Efficiency of Various Nicotine Compounds for the Control of the Codling Moth. (5 min.) S. W. Harman, T. W. Reed and G. L. Mack, Geneva, N. Y. (Lantern).

The insecticidal efficiency of such nicotine combinations as "B. L. 155," oil-nicotine, Kolofog-nicotine, and bentonite-nicotine is discussed. These sprays were tested under field conditions in a district seriously infested with the codling moth. The persistence of their residues as determined by chemical analyses is also considered.

To Be Read By Title

26. Codling Moth Experiments in Southeastern Michigan. Franklin Sherman III, East Lansing, Michigan.

Progress report on control experiments on codling moth in orchards in southeastern Michigan.

27. Preventing Spring Emergence of Codling Moths from Inaccessible Places on Trees. G. Edward Marshall, Bedford, Indiana.

Program

Thursday Evening Session, December 27, 7:30 P. M. Cardinal Room

SECTION OF APICULTURE

W. H. BRITTAIN, *Chairman* W. A. PRICE, *Secretary*

Appointment of Committees on Resolutions and Nominations.

Address of the Chairman, W. H. Brittain, Quebec, Canada. "Bee Activity During Apple Bloom."

1. Results of Investigations on Wintering in the Light of Last Winter. E. F. Phillips, Ithaca, N. Y.

2. The Effect of Certain Bactericides, especially Copper Sulfate, on the Longevity of Honeybees. E. M. Hildebrand and E. F. Phillips.

This paper gives the results of numerous feeding tests in which bactericides were included in food given honeybees which were caged, to determine whether they are repellent or toxic.

3. Some Effects of Relative Humidity on the Metabolism of Honeybees. A. W. Woodrow, Ithaca, N. Y.

This is a report of an investigation on the influence of relative humidity on the length of life and the food consumption of bees.

4. Soil Preference of Certain Honey Plants. E. Oertel and M. C. Lovett, Baton Rouge, Louisiana.

5. The Cause of Dysentery of Honeybees. H. F. Wilson, Madison, Wisconsin.

6. The Influence of Colony Population on Honey Production. C. L. Farrar, Laramie, Wyoming.

A statistical method is presented for standardizing honey flow data which are represented by differences due to locality, season, or partial season, to a constant level of honey flow intensity. The production factors per thousand bees increased rapidly as colony populations increased from 15 to 60 thousand bees.

7. Further Observations on the Flight Range of the Honeybee in Relation to Honey Production. A. P. Sturtevant and C. L. Farrar, Laramie, Wyoming.

Observations on the effect of distance of colonies of bees from the nectar source were continued under commercial conditions. During two successive seasons the colonies in apiaries located within and entirely surrounded by a good nectar source made distinctly greater net gains in weight than did colonies in apiaries located from 1.2 to 1.5 miles outside and away from the nectar source. The outside colonies, however, were able to make appreciable commercial gains even under the handicap of distance from the nectar source.

8. Studies on the Bacteria Associated with Parafoulbrood. C. E. Burnside and Robert E. Foster, Washington, D. C., and Gainesville, Fla.

The bacteria associated with parafoulbrood vary markedly in morphological and cultural characteristics. The vegetative forms resemble those present in European foulbrood. The sporogenic stage of *Bacillus para alvei*, which is also described, appears related to *Bacillus alvei* but can be readily distinguished. The etiology of parafoulbrood is unsettled, but appears to be similar to that of European foulbrood. Evidence is presented supporting the authors' belief that the etiological factor in parafoulbrood is a pleomorphic bacterium of which *Bacillus para alvei* appears to be a stage in the life history.

9. Honeybees Attacked by Ants in the Mountains of California. G. H. Vansell and F. H. Wymore, Davis, California.

Bees moved up to 6000 ft. elevation were seriously weakened by the ant *Formica rufa* Linn. Studies of the nest and habits indicated the feasibility of fumigation. Calcium cyanide gave excellent control.

10. Observations on the Habits and Variation in Size of the Greater Wax Moth, *Galleria mellonella* L. H. W. Geuther and V. G. Milum, Urbana, Illinois.

11. Airplane Dusting and its Relation to Beekeeping. J. E. Eckert and H. W. Allinger, Davis, California.

A detailed account is given of the manner in which bees are injured by dusts applied in the control of insect pests as well as evidence to show that the injury is greatly aggravated when these dusts are applied by airplane, due largely to the drift of the dust that invariably occurs with such applications. Chemical dusts are fast becoming one of the major hazards of beekeeping and are considered by the writer as one of the prime causes of the gradual disappearance of bees from farms.

12. Are Some Honeybees Immune to *Bacillus larvae*? Roy G. Richmond, Fort Collins, Colorado.

Bacillus larvae has killed hundreds of thousands of colonies of bees in the United States. Control of the disease has been accomplished by treatment of the diseased colony rather than by preventative methods. Recent experiments, by the State Bureau of Plant and Insect Control in Colorado, indicate that some strains of bees may have a form of immunity to the disease.

Report of Committees.

Selection of Officers.

Adjournment.

Program

Thursday Evening Session, December 27, 7:30 P. M. Silver Room

SECTION OF EXTENSION

M. P. JONES, *Chairman* W. E. BLAUVELT, *Secretary*

Appointment of Committees on Nominations and Resolutions.

1. Screw Worm Control Campaign. M. P. Jones, Washington, D. C.

2. Informal Discussion of Codling Moth Control Programs from the Viewpoint of the Extension Entomologist. Discussion Leader T. J. Headlee, New Brunswick, N. J.

Brief reports by H. E. Hodgkiss, State College, Pa.; W. S. Hough, Winchester, Va.; T. H. Parks, Columbus, Ohio; and W. E. Blauvelt, Ithaca, N. Y.

3. Informal Discussion of Field Results with Arsenical Substitutes in the Control of Vegetable Insects. Discussion Leader E. N. Cory, College Park, Md.

Report of Committees.

Selection of Officers.

Adjournment.

Program

MEETING OF EXECUTIVE COMMITTEE

At this meeting will be presented all committee reports, except those scheduled for the final business session.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Governors of the Crop Protection Institute, by W. C. O'Kane, Durham, N. H.

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio.

Report of the Representative on the Council of the Union of Biological Societies, by C. R. Crosby, Ithaca, N. Y.

Report of the Committee on Nomenclature, by J. A. Hyslop, Washington, D. C.

Report of Board of Trustees for Permanent Fund, by A. I. Bourne, Amherst, Mass.

Report of Joint Committee on Insect Collections, by T. H. Frison, Urbana, Ill.

Report of the Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, by B. A. Porter, Washington, D. C.

Report of the Committee on Research Work on the Control of the European Corn Borer, by J. J. Davis, Lafayette, Ind.

Report of the Committee on Training of Entomologists, by C. J. Drake, Ames, Iowa.

Report of Special Committee on Policy of the Journal of Economic Entomology, by H. J. Quayle, Riverside, Cal.

Report of Special Committee for Investigation of Reorganization of Entomological Research in the Federal Government, by E. F. Phillips, Ithaca, N. Y.

Report of Program Committee, by J. G. Sanders, Philadelphia, Pa.

Report of the Committee on Publicity, by E. P. Felt, Stamford, Conn.

Program

Friday Morning Session, December 28, 9:00 A. M. Urban Ball Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Report of Secretary.

Report of Executive Committee.

Additional reports determined advisable by the Executive Committee to be presented to the General Session.

Reading of Papers

INSECTICIDES

28. Sulphated Alcohols in Insecticides. (5 min.) Ernest N. Cory and George S. Langford, College Park, Maryland.

Summary of preliminary tests on the insecticidal, emulsifying and spreading qualities of sulfated alcohols.

29. Oil Sprays on Apple Trees. (5 min.) M. D. Farrar, Urbana, Ill.

Results of yearly applications of oil emulsions to dormant and growing apple trees, over 5 and 10 year periods.

30. Some Recent Developments in Regard to Tar Distillate Sprays. (5 min.) F. Z. Hartzell, S. W. Harman and T. W. Reed, Geneva, N. Y. (Lantern).

The subjects include efforts at standardization, dosages for specific insects and conditions necessary to secure adequate control with a minimum of injury to susceptible trees.

31. Diesel Oil Emulsions as Insecticides. (15 min.) Walter Carter, Honolulu, Hawaii. (Lantern).

Emulsification on colloidal clay: variation due to source of clay: limits of oil-holding capacity of clays: necessity for high-speed mixing: method for increasing adsorption surface of Bentonite clay, and effect of this increase on emulsion characteristics. Dilution of emulsions in spray tank: dispersal of Bentonite particles by use of acid diluent: by other colloids: effect of dispersal on phytocidal characteristics of oil. Pineapple anatomy and susceptibility to oil injury: seasonal effects: comparison with other types of leaf burn: absence of injury to citrus and ornamentals. Tests of insecticidal efficiency with low oil concentrations: field experiments on mealy bug control: control of mealy bug wilt: control of green scale: of *Parlatoria* scale.

32. Relationships between Chemical Composition and Insecticidal Effectiveness of Rotenone-Bearing Plants. (10 min.) Howard A. Jones, F. L. Campbell and W. N. Sullivan, Takoma Park, Md. (Lantern).

The rotenone content, amount of material extracted by organic solvents, methoxyl content, optical rotation of extracts and other chemical properties of samples of derris root, cube root, haiari stem and *Cracca virginiana* root are compared with the toxicity of their extracts to house flies.

33. Chemicals Tested as Arsenical Substitutes. (10 min.) Joseph M. Ginsburg, New Brunswick, N. J. (Lantern).

The insecticidal properties of several groups of organic and inorganic compounds against chewing insects were studied, using the silk moth larva (*Bombyx mori*) as "insect indicator." The chemicals possessing toxicity and repellency to insects are discussed.

34. The Collection and Analysis of Data on the Value of Non-arsenical Insecticides for the Control of Cabbage Worms. (12 min.) George M. List and Leonard Sweetman, Fort Collins, Colo.

A method is presented treating the problem of evaluating results of applying certain insecticides to cabbage. A count of larvae before and after treatment is the important feature as it eliminates the two variables of number of applications and worm population through the season and deals only with the strength of material and its effect upon the Imported Cabbage Worm. The method removes the personal element which enters when the amount of injury is classified. The method, which allows statistical treatment for the computing of errors due to chance which enters into field experiments, is a modification of the per cent-kill method. Derris, cube and pyrethrum powders were used, as well as pyrethrum

extracts, in comparison with calcium arsenate, lead arsenate, paris green, and cryolite. Different dilutions of the non-poisonous insecticides were used. A portion of the season's data is presented, enough to justify the experimental method followed, and enough to show the more important conclusions to be drawn from the season's work.

35. The Control of Some Ectoparasites of Laboratory Rats by Atomized Pyrethrum Extracts in Oil. (5 min.) E. M. Searls and Fred M. Snyder, Madison, Wisconsin.

Bedbugs (*Cimicidae*), sucking lice (*Anoplura*), and some mites (*Acarina*) on laboratory rats may be effectively controlled by spraying with an atomized solution of pyrethrum extracts in a highly refined kerosene oil. Physiological studies showed that the rats were not injured by the treatment.

36. A New Spreader for Nicotine. (5 min.) C. O. Eddy, Lexington, Ky.

37. The Performance of Inorganic Insecticide Dusts in the Control of Cucumber Beetles. (8 min.) H. F. Dietz and E. E. Zeisert, Wooster, Ohio. (Lantern).

The relative ratings derived from several ways of evaluating performance are given for calcium arsenate, manganese arsenate (compound), and barium fluosilicate (Dutox) dusts. The influence of various diluents also is shown.

38. The Vacuum Fumigation of Flour Products with HCN. (5 min.) H. D. Young, Geo. B. Wagner and R. T. Cotton, Manhattan, Kansas.

The degree of penetration into packaged flour of HCN and its subsequent absorption by the flour is dependent upon the vacuum obtained, the length of time the vacuum is maintained, the concentration of the gas, the size of the package and the amount of flour fumigated. In determining the dosage that will successfully kill flour beetles infesting flour products all these facts must be considered.

39. A Method for Comparing the Ovicidal Properties of Contact Insecticides. (10 min.) E. P. Breakey and A. C. Miller, Columbus, Ohio. (Lantern).

A method is proposed for comparing the ovicidal properties of substances commonly employed as contact insecticides. An attempt is made to arrive at a standard procedure, using the eggs of an insect of wide distribution, whose life history lends itself readily to such a practice. The growing interest in the ovicidal properties of contact insecticides, and the apparent lack of any common method for ascertaining and comparing these inherent qualities, prompt the writers to outline in some detail the technique used by them.

40. Halowax as an Ovicide. (10 min.) E. P. Breakey and A. C. Miller, Columbus, Ohio. (Lantern).

The insecticidal properties of Halowax, a chlorinated naphthalene product, have been discussed by the senior writer (Jl. Econ. Ent. 27: 393–398). The present paper deals with the ovicidal properties of this product as compared with those of other contact insecticides. The method used in determining and comparing the ovicidal properties of these substances is that described by the writers elsewhere on this program.

To Be Read By Title

41. Volatilization of Oils Used in Oil Spray Emulsions. M. B. Hatch and R. H. Robinson, Corvallis, Oregon.

Losses by volatilization of oil observed in a temperature controlled cabinet and out of doors during the summertime have been determined for fifteen different oils used by manufacturers in the preparation of oil emulsion sprays. Two series were run over periods of two weeks, four weeks, and eight weeks each, wherein the oil was impregnated in paper sheets and on each side of glass plates. The losses recorded indicate in a general way the amount of oil that may remain on sprayed trees and fruits after the periods of exposure indicated.

42. Silicates of Soda Incorporated with Lead Arsenate in the Last Regular Spray an Aid to Residue Removal. Charles L. Fluke, Madison, Wisc.

Certain silicates of soda added to the last regular spray for apples at the rate of one pound to forty gallons of spray assisted the natural weathering of lead and arsenic residues and increased the efficiency of their removal with silicates at picking time.

43. Further Investigations on Oil Deposit. Ralph H. Smith and John P. LaDue, Riverside, Cal.

The paper presents data showing the relation of oil deposit to control and injury, and presents a practical method for determining oil deposit by extraction of the oil from sprayed leaves.

44. Four Years of Experience with Tank Mixture Spray. Ralph H. Smith, Riverside, Cal.

Presents data on the extensive use of tank mix spray in the spraying of citrus trees in California during the past four years.

Program

Friday Afternoon Session, December 28, 1:30 P. M. Urban Ball Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Invitation Papers

The Grasshopper Outbreak, 1931–1934, in Canada. H. Gordon Crawford, Ottawa, Canada.

The 1934 Grasshopper Outbreak. J. R. Parker, Bozeman, Montana.

Mosquito Control Work of Today. F. C. Bishopp, Washington, D. C.

The Importance of the Chinch Bug to Midwest Agriculture. W. P. Flint, Urbana, Ill.

The Corn Borer Problem. J. J. Davis, Lafayette, Indiana.

Entomological Phases of the Dutch Elm Disease. Philip A. Readio, Ithaca, N. Y.

Program

Saturday Morning Session, December 29, 9:30 A. M. Urban Ball Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

Section A

INSECTS AFFECTING DECIDUOUS FRUITS

45. Comparative Effectiveness of Fluorine Compounds, Lead Arsenate and Jarring Peach Trees for the Control of the Plum Curculio. (5 min.) Oliver I. Snapp, Fort Valley, Georgia. (Lantern).

Results of experiments conducted on large blocks of peach trees.

46. 1934 Notes on Baits for Oriental Fruit Moth. (5 min.) S. W. Frost, Arendtsville, Pa.

A brief paper summarizing comparative catches of oriental fruit moth from forty new baits tried during 1934.

47. Variations in Seasonal Prevalence of Oriental Fruit Moth Adults in Peach and Quince Orchards. (5 min.) R. B. Neiswander, Wooster, Ohio. (Lantern).

Bait trap records demonstrate moth prevalence in greater abundance in quince in early and late season and in peach in mid-season.

48. Notes on the Biology and the Developmental Stages of *Glypta rufiscutellaris* Cress., (Braconidae, Hymenoptera), a Larval Parasite of the Oriental Fruit Moth. (5 min.) B. Elwood Montgomery, Lafayette, Ind. (Lantern).

The larval instars of this parasite are described and figured; the degree of parasitism obtained decreased as the age of the host larva at time of inoculation increases. Some notes on the biology of the parasite are included.

49. Larvicidal Efficiency of Certain Spray Combinations Against the Fruit Tree Leaf Roller. (5 min.) P. J. Chapman and R. W. Dean, Geneva, N. Y. (Lantern).

Control experiments were conducted in 1934 against the leaf roller, *Cacoecia argyrospila* Walker, in an apple orchard where, on unsprayed trees, 50 per cent or more of the crop was totally destroyed and of the fruit which matured 45 to 80 per cent was badly scarred. Lead arsenate gave a calculated control efficiency of 52.3 per cent, lead arsenate and summer oil 90.1 per cent, and lead arsenate with summer oil and nicotine sulfate 93.8 per cent. Other insecticides tested include: calcium arsenate, ground derris root, cryolite and summer oil, nicotine sulfate and summer oil, nicotine sulfate and bentonite (Black Leaf 155), nicotine sulfate and bentonite-sulfur, and nicotine sulfate with ammonium sulfo soap. Nicotine possesses some value, at least, as a larvicide against this species. Two

treatments were applied, one just before and the others directly after blossoming. The leaf roller eggs hatched during the blossom period.

50. The Biology of the Apple Aphids in Relation to Fall Spraying. (10 min.) T. Walter Reed, Geneva, N. Y. (Lantern).

A study of the biology of the apple aphids during the fall months and the response of the aphids and trees to treatment with various insecticides.

51. Immediate and Residual Effects of Certain Insecticides on the White Apple Leafhopper. (5 min.) Harold M. Steiner, Poughkeepsie, N. Y. (Lantern).

Field and laboratory tests of certain insecticides on nymphs of the white apple leafhopper, *Typhlocyba pomaria* McAtee, indicate that nicotine sulphate dilutions of 1–2400 or less, when used with small amounts of some commercial soap flakes, give immediate control comparable with that obtained from the most promising materials tested and provide a residue that is toxic to nymphs hatching several days after spray applications are made.

52. Strawberry Leaf-roller Control by Non-Poisonous Insecticides. (5 min.) Ray Hutson, East Lansing, Michigan.

Detailed report of control experiments using non-poisonous insecticides against *Ancylis comptana*.

53. Population Studies of Soil Insects in Relation to the Abundance of Raspberry Crown Gall. (5 min.) A. A. Granovsky, St. Paul, Minn. (Lantern).

Survey of soil insects during four years in several commercial raspberry plantations, following different types of ground covers, has shown a definite correlation between the abundance of soil arthropods and the raspberry crown gall. Two years of methodical reconnaissance by digging for the density of soil insects prior to selection of suitable fields for raspberry planting proved to be of decided value in reduction of the abundance of crown gall.

To Be Read By Title

54. The Successful Introduction of the Woolly Apple Aphis Parasite, *Aphelinus mali* Hald., in the Wenatchee, Washington District. M. A. Yothers, Wenatchee, Washington.

Summary of the introduction, rearing, liberation and successful spread of *Aphelinus mali* on its woolly aphis host in orchards of the Wenatchee, Washington district.

Insects Affecting Forest and Shade Trees and Ornamentals

55. Important Shade Tree Insects in 1934. (5 min.) E. P. Felt, Stamford, Conn.

A discussion of the economic status of a number of species.

56. Distribution and Notes on the Lesser Elm Bark Beetle in N. Y. State (*Scolytus multistriatus*). (5 min.) Henry Dietrich, Ithaca, N. Y. (Lantern).

Detailed distribution of *Scolytus multistriatus* in N. Y. state.

57. Control Experiments on the European Pine Shoot Moth, *Rhyacionia* (*Evetria*) *buoliana* Schiff., with Special Reference to the Problem in Reforestation Work. (10 min.) Robert D. Glasgow, Albany, N. Y. (Lantern).

The State of New York is committed to a program that calls for reforesting 2,000,000 or more acres of abandoned farm land. The European pine shoot moth, *Rhyacionia* (*Evetria*) *buoliana* Schiff., first reported in America in 1914, seems amply to have demonstrated its power to become a pest of the first magnitude on desirable pine species, and so to have become a major problem under reforestation conditions in that State. This led the Legislature in 1933 to amend the gypsy moth law to read "—the gypsy moth and/or the European pine shoot moth—" and to make both insects subject to the same drastic regulatory measures; and it has prompted a search for economically practical measures for control of this relatively new pest in reforestation plantings. Measures adapted for control of this pest on ornamental pines and in nurseries have continued to prove apparently effective. More directly concerning the reforestation problem, however, a single thorough application of an arsenical dust each year has given excellent control for two successive years under conditions that were extremely favorable for heavy oviposition upon, and reinfestation of the treated trees, if the protection afforded is likely to be broken down. Results of these experiments suggest that a single properly timed application of an arsenical dust from an airplane to an infested forestry plantation might give adequate control, and that under reforestation conditions even this single application probably need not be repeated each year.

58. The Pales Weevil an Important Pest in Nurseries and in Reforestation Plantings. (5 min.) Robert D. Glasgow, Albany, N. Y. (Lantern).

The adult Pales weevil, *Hylobius pales* Boh. may injure severely or may even kill young pine trees by feeding on the bark. The larvae of this insect may injure or kill pine trees of considerable size by eating the bark from the larger roots, and from the collar of the tree just below the surface of the ground. In New York this insect has injured or killed many Scotch pine trees and other pines in reforestation plantings, and has killed or severely injured Mugho and other pines in Nurseries.

59. The Pecan Tree-Borer in Dogwood (*Synanthedon scitula*). (5 min.) G. W. Underhill, Blacksburg, Va.

Some observations and notes on the life history, habits and economic status as a dogwood pest in Virginia.

60. A New Species of Mite (*Neotetranychus buxi*, n. sp. Garman) on Boxwood. (5 min.) Donald T. Ries, Ithaca, N. Y. (Lantern).

61. Control Measures for the Arbor-Vitae Leaf Miners (Lepidoptera). (5 min.) A. E. Brower, Bar Harbor, Maine.

The importance, biology, and control of the species concerned will be discussed.

62. Cold Storage as a Control Measure for the Gladiolus Thrips, (*Taeniothrips gladioli* M. & S.). (5 min.) R. H. Nelson, Clarendon, Va. (Lantern).

The results of two seasons experiments show that all stages of this insect can be killed by storing the infested corms at a constant temperature of 36 degrees F. for two months, or of 40 degrees F. for three months.

63. A Progress Report on the Control of the Mexican Mealybug (*Phenacoccus gossypii* T. & Ckll.) on Greenhouse Chrysanthemums. (10 min.) H. H. Richardson, Washington, D. C. (Lantern).

The effectiveness of calcium cyanide fumigations and kerosene emulsion as well as other insecticides is discussed with data on plant tolerance. The relative susceptibility of this mealybug is also discussed with other greenhouse mealybugs.

64. Experiments in the Control of the Mexican Mealybug, *Phenacoccus gossypii* T. & Ckl. (5 min.) C. R. Neiswander, Wooster, Ohio. (Lantern).

An aliphatic thiocyanate has been found effective in controlling this insect.

To Be Read By Title

65. The Holly Scale, *Aspidiotus britanicus*, and Other Insect Pests of English Holly in Oregon. J. R. Roaf and Don C. Mote, Corvallis, Ore.

The most important insect pest of English holly in Oregon is the holly or laurel scale, ***Aspidiotus britanicus*** Newstead. Although apparently a European insect, it has been present in Oregon for at least 36 years, but has attracted little attention until recently, due largely to an increasing interest in the production and exportation of Christmas holly. Plant quarantines restricting the free movement of the scale infested Christmas holly have focused the attention of the growers upon this scale insect and created an immediate need for information upon the life habits and control of the pest. The holly scale passes the winter in an immature stage; matures in late spring; the female lays about 100 eggs each in the late spring and early summer, which hatch in 4 to 6 days. Two chalcid parasites, ***Aspidiotiphagus citrinus*** (Craw.) and ***Aphycas*** (***Aphelinus***) ***mytilaspidis*** (Le Baron), were reared from the scale. Limited control tests indicate that spraying the infested trees with an oil emulsion, 3 to 100, viscosity 75 Saybolt; sulfonation test not less than 85) in early spring is of value in combating the scale; that fumigation with calcium cyanide dust is also of value. Further work, however, is needed upon materials, methods, and time of application. Observations on effectiveness of materials used for making Christmas holly safe for shipment indicated the need of additional experimental work in this field. As a result of the studies, the California authorities lifted their ruling upon Christmas holly wreaths and buttonaires.

Section B, Silver Room

Insects Affecting Field, Cereal, and Forage Crops

66. Chinch Bug Barriers and Repellents. (5 min.) W. P. Flint, M. D. Farrar, W. E. McCauley. (Lantern).

This is a summary of several years comparisons of different chinch bug repellent chemicals and of two years work with mechanical barriers of various types. Certain types of mechanical barriers offer promise, especially one type of metal and the corrugated paper barrier.

67. A Comparison of Certain Materials Used as Chinch Bug Barriers. (5 min.) L. L. Huber and J. S. Houser, Wooster, Ohio. (Lantern).

This paper deals not only with the results of an experiment, but also the methods.

68. The Alfalfa Snout Beetle, a Dangerous Imported Alfalfa Pest in New York State. (15 min.) P. W. Claassen and C. E. Palm. (Lantern).

The Alfalfa Snout Beetle, *Brachyrhinus ligustici* L., an important alfalfa pest in Europe has become established in Oswego and Jefferson Counties in N. Y. A number of alfalfa fields have already been completely destroyed by this pest. Investigations during the past season have been limited to the distribution, biology and control of this insect.

69. The Effect of Food Plants on the Development of the Pale Western Cutworm. (5 min.) H. L. Seamans and H. Ellis McMillan, Alberta, Canada.

The pale western cutworm (*Agrotis orthogonia* Morr.) apparently feeds on almost any plant growing in the fields so that for many years these larvae have been reared in the laboratory on dandelion or wandering Jew. Rearing records have shown the development of the larvae to be very irregular and the period of larval life to be from two to four times as long in the laboratory as in the field. The death rate of reared larvae has been very high, a condition which has not been encountered in the field. Several series of larvae have been reared during the past two years each on a different food plant. The results of this work indicate that the food plant may materially affect the larval development and that the majority of past rearing records are in no way comparable to the actual development in the field. There is also an indication that an abundance of the wrong food plant in the field may be a natural control factor of the species.

70. Forecasting Outbreaks of the Pale Western Cutworm. (5 min.) H. L. Seamans, Alberta, Canada.

During the winter of 1922–23 a method of forecasting outbreaks of the pale western cutworm (*Argotis orthogonia* Morr.) was worked out for the Canadian prairies based on weather data. This method was published in the Canadian Entomologist in March 1923, and was used to forecast the outbreak that season. The first published forecast of expected outbreaks of pale western cutworm was sent to the press in July 1923, and this has become an annual procedure ever since. As the only control for this insect is a cultural practice which must be observed

during August and early September, the forecast is particularly valuable, since it is made in time to enable farmers to carry out the control measures. This paper is a review of ten years forecasting outbreaks and the results that have been obtained. In the last few years the forecast has covered the greater part of the wheat growing areas of Alberta and Saskatchewan with surprising accuracy, and its value to the farmers is reflected in the increasing numbers who are following the control practice when necessary.

71. An Economic Survey of Pale Western Cutworm Damage in Saskatchewan. (5 min.) H. Ellis McMillan, Alberta, Canada.

The pale western cutworm (*Agrotis orthogonia* Morr.) is one of the most important grain pests of the Northern Great Plains area of Canada and the United States. In order to determine the actual losses caused by this insect, an intensive survey was conducted in northern Saskatchewan during the severe outbreak of 1931. The area chosen for this survey was one where the pale western cutworm was the main factor detrimental to crops and where drought and soil drifting were practically negligible. The survey covered the greater part of seven townships, and practically every field in this area was included. The actual losses in seed, labor, reduced yield, costs of reseeding, and the value of the second crop are figured in dollars and cents. These losses are shown for the different crops grown, and cultural preparations for each crop as well as the recommended cultural control for the insect. The values used in making the determinations were based on the prices at local elevators at the time the survey was made. The survey has shown that various cultural methods preceded the seeding of the crop and that losses varied with the method used. It has also indicated that some crops are more seriously injured than others grown under the same conditions.

72. The Tomato Pin Worm: Present Status in Pennsylvania. (5 min.) Charles A. Thomas, Kennett Square, Pa.

The history of the Pin Worm in Pa.; notes on the biology, life history and natural control; results of control experiments.

73. The Psyllid Yellows of Tomatoes and Control of the Psyllid, *Paratrioza cockerelli* Sulc, by the Use of Sulphur. (15 min.) George M. List, Fort Collins, Colorado. (Lantern).

The psyllid yellows of tomatoes is a serious problem for tomato growers in Colorado. The growth of psyllid infested plants becomes abnormal with the yield and quality of the fruit much lowered. Dusting sulphur has proven as effective as lime-sulphur in controlling the insect without apparent injurious effects as often result from the use of the lime-sulphur.

74. The Effect of Light Reflected by Bordeaux Sprayed Plants on Populations of Potato Aphids. (5 min.) Joseph B. Moore, Ithaca, N. Y. (Lantern).

Preliminary studies showing correlation between intensity of reflected light and aphid population.

75. Hibernation Studies of the Potato Leafhopper (*Empoasca fabae* Harr.) and Related Species of Empoasca Occurring in Ohio. D. M. De Long and J. S. Caldwell, Columbus, Ohio.

Experiments attempting to hibernate *Empoasca fabae* in Ohio for several years have proved unsuccessful and extensive search has not revealed it in hibernating quarters although several of the less common species have been found to hibernate under Ohio conditions.

76. Injury to Alfalfa and Red Clover by the Potato Leafhopper. (10 min.) F. W. Poos and H. W. Johnson, Rosslyn, Va. (Lantern).

A report on experiments showing that the degree of injury to certain varieties of alfalfa and red clover was proportional to the amount of leafhopper infestation. Losses in yield to alfalfa were determined in cages over a period of five years. Further work is reported on the choice of varieties for oviposition by this leafhopper.

77. A Factor Influencing Reduced Yields in Potato Spraying Experiments on Long Island. (10 min.) W. A. Dickison, Ithaca, N. Y. (Lantern).

An attempt to explain one factor which has operated to prevent increased yields from spraying in potato spraying experiments for five successive years in Nassau County, Long Island.

78. Derris and Other Insecticides for the Control of the Mexican Bean Beetle. (5 min.) N. F. Howard, L. W. Brannon and H. C. Mason, Columbus, Ohio.

Discusses results secured with derris and various other insecticides employed against the Mexican bean beetle with special reference to the elimination of the arsenical residue hazard.

79. Some Effects of the Environment on the Oviposition of the Bean Weevil, *Bruchus obtectus* Say. (10 min.) H. Menusan, Jr., Ithaca, N. Y. (Lantern).

Rate and total oviposition of bean weevils at constant light, temperature, and humidity.

80. Ovicidal Tests on Certain Dipterous Eggs, with Especial Reference to the Onion Maggot. (5 min.) J. P. Sleesman, Wooster, Ohio. (Lantern).

81. *Trachelus tabidus* (Fab.), A Serious Wheat Pest. (5 min.) J. S. Houser, Wooster, Ohio. (Lantern).

Fields carrying a 50% infestation were common in eastern Ohio in 1934.

82. Sulphur Fumigation for the Control of Mushroom Pests. (15 min.) A. C. Davis, Takoma Park, Md. (Lantern).

Determination of concentration and time of exposure necessary to give complete kill of mushroom pests under mushroom house conditions.

83. Factors Relating to the Control of the Mushroom Mite, *Histiostoma gracilipes* Banks. (5 min.) C. C. Compton, Urbana, Ill.

The mushroom mite, ***Histiostoma gracilipes*** Banks, has caused heavy losses to mushroom growers in Illinois during the past five years. The control of this mite is dependent upon several factors, namely, proximity to mushroom houses of compost piles and deposits of old compost, heating of the beds after filling, fumigation at peak heat and control of various mushroom flies.

84. The Relation of Entomologists to the Exterminating Business. (15 min.) George L. Hockenyos, Springfield, Illinois.

To Be Read By Title

85. Chloropid Populations on Pasture Grasses in Kansas (Diptera, Chloropidae). Donald A. Wilbur and Curtis W. Sabrosky, Manhattan, Kansas.

Regular collections on areas of both native and introduced pasture grasses near Manhattan, Kansas, over a period of three years, have yielded considerable data on many species of insects. The present paper, based on approximately 11,000 specimens of the Dipterous family Chloropidae, records the occurrence of 49 species, together with notes on their relative abundance, seasonal distribution, and number of generations.

86. Hybrid Vigor and Adaptation in Relation to Chinch Bug Resistance in Corn. Reginald H. Painter, Ralph O. Snelling and Arthur M. Brunson, Manhattan, Kansas.

First generation hybrids of corn usually greatly exceed either of the parent inbreeds in resistance to Chinch bug. Data are given on the resistance to Chinch bugs of a number of corn varieties at Lawton, Okla. and Manhattan, Kansas.

87. Hibernation of Pea Aphid Eggs with and without Protective Coverings. Theodore E. Bronson, Madison, Wisconsin.

Paper gives data on hibernation of eggs with and without coverings, winter temperatures, and hatching results in the spring.

88. Species and Distribution of Grasshoppers Responsible for the 1934 Outbreak. R. L. Shotwell, Bozeman, Montana.

This paper gives the quantitative distribution of the species of grasshoppers that were found in various crops and types of vegetation during the 1934 outbreak.

Program

Saturday Afternoon Session, December 28, 1:30 P. M. Urban Ball Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Symposium on International Entomological Problems

The Cooperation of Canada and the United States on Insect Problems. Arthur Gibson, Dominion Entomologist, Ottawa, Canada.

International Problems in Plant Quarantines and Pest Control Common to Mexico and the United States. A. Dampf, Government Entomologist, Mexico.

Entomological Work in the United States with Special Reference to Problems It Has in Common with Canada and Mexico. Lee A. Strong, Chief, Bureau of Entomology and Plant Quarantine, Washington, D. C.

FINAL BUSINESS

Report of the Committee on Resolutions.

Report of the Committee on Membership.

Report of the Special Committee on the International Congress at Madrid.

Report of other Committees.

Nomination of Journal Officers by Advisory Committee.

Report of Committee on Nominations.

Election of Officers.

Miscellaneous Business.

Fixing Time and Place of Next Annual Meeting.

Final Adjournment.

E. F. PHILLIPS, *President*
Ithaca, N. Y.

A. I. BOURNE, *Secretary*
Amherst, Mass.

Vol. 27, 1934

JOURNAL

OF

ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

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PUBLISHED BY
AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
GENEVA, N. Y.

Entered March 14, 1921 as second-class matter at the Post-Office at Geneva, N. Y., under the Act of Congress of March 3, 1879.

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[1]Abstract
[2]Withdrawn for publication elsewhere

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[1]Abstract

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 27 DECEMBER, 1934 No. 6

VARIATION IN THE NUMBER OF EGG TUBULES IN THE QUEEN BEE[1]

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Beekeepers have known for many years that a considerable variation exists in the production of adult bees in the different colonies of an apiary. Oertel[2] has shown that there is a large variation in the number of egg tubules in the ovaries of queen bees furnished by one queen breeder. The following investigation was begun to determine the variation in the number of egg tubules in queens obtained from several queen breeders.

METHOD.—Most of the laying queen bees were obtained from breeders in the South. These queens were usually killed and fixed in Bouin's solution before they were sent to the laboratory. Unfortunately, it is not known whether all the queens in each lot were daughters of the same mother. All the virgin queens were obtained at the laboratory in Baton Rouge.

After abdominal measurements of the laying queens had been made, the ovaries were dissected out, sectioned, and stained. The right and the left ovary of each queen was handled separately. The number of egg tubules was determined by actual count from the transverse sections. Occasionally an ovary was injured in handling and had to be discarded.

LAYING QUEEN BEES.—The variation in the number of egg tubules in the ovaries of laying queen bees is given in Table 1. Queens obtained from different queen breeders are designated as A, B, C, etc., and each lot has been kept separate. In lot A the number of egg tubules ranges

[1]A contribution from the Southern States Bee Culture Field Laboratory, Baton Rouge, La., maintained by the Division of Bee Culture, Bureau of Entomology, U. S. Department of Agriculture, in cooperation with the Louisiana State University.

[2]Oertel, E. Number of egg tubules in queen bee ovaries. Amer. Bee Jour. 71: 118. 1931.

TABLE 1. VARIATION IN NUMBER OF EGG TUBULES IN THE OVARIES OF LAYING QUEEN BEES

Number of queens.....	7		5		24		11		15		11		73	
	Number of ovaries													
Number of egg tubules	Laboratory apiary		Lot A		Lot B		Lot C		Lot D		Miscellaneous		Total	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
75–85.....	–	–	–	–	1	–	–	–	–	–	–	1	1	1
86–95.....	–	–	–	1	–	–	–	–	1	3	–	1	1	5
96–105.....	–	–	–	–	2	5	–	–	1	3	2	1	5	9
106–115.....	–	–	2	2	7	5	4	2	5	2	1	1	19	12
116–125.....	1	–	2	2	9	4	4	3	4	3	1	4	21	16
126–135.....	2	2	–	–	4	3	1	2	1	2	1	2	9	11
136–145.....	1	3	–	–	1	2	1	1	1	–	–	–	4	6
146–155.....	1	1	1	–	–	1	–	–	–	–	1	–	3	2
156–165.....	–	–	–	–	–	–	–	–	–	–	–	–	–	–
166–175.....	–	–	–	–	–	–	–	–	–	–	–	–	1	–
Total.....	5	6	5	5	24	20	10	8	13	13	6	10	64	62

from 86 to 155, in lot B from 75 to 155, in lot C from 106 to 145, in lot D from 86 to 145, in the miscellaneous lot from 75 to 155, and in the laboratory apiary lot from 116 to 175. The number of queens composing some of the lots is rather small for this type of work. Lots B and C are related; that is, the beekeeper who furnished lot B obtained some of his breeding stock from the breeder who furnished lot C. Since there is some interchange of breeding stock by many queen breeders, bees may be more closely related than is generally recognized. The right ovary usually contains a larger number of tubules than the left ovary, but in some of the queens the left ovary contains the greater number of tubules. There seems to be no particular significance attached to this phenomenon.

The variation between the different lots of laying queens has been analyzed according to Fisher's method.[3] Table 2 gives the mean number of egg tubules for the different lots of queens. The value of z was found to be 0.846, which is larger than the 0.6972 of the 1 per cent point of the distribution of z. The variation between lots of queens used in this study is without question significant. Whether this variation is of any practical importance to the beekeeper is not yet known. It is recognized that the queens from the laboratory apiary are largely responsible for the variance between groups. There is little variation between lots A, B, C, and

TABLE 2. NUMBER OF EGG TUBULES FROM BOTH OVARIES OF LAYING QUEENS FROM DIFFERENT LOTS

Count	Laboratory apiary	Lot A	Lot B	Lot C	Lot D
Individual	280	270	280 225	245	210
	285	215	240 230	220	220
	265	225	215 230	230	210
	270	245	205 250	280	205
	260	220	245 235	245	200
	—	—	210 270	245	270
	—	—	232 250	235	225
	—	—	210 210	250	230
	—	—	255 245	—	210
	—	—	225 285	—	240
	—	—	— —	—	210
	—	—			
Total	1,360	1,175	4,747	1,950	2,430
Mean	272	235	237.35	243.75	220.909

Analysis of the Variance

	Degrees of freedom	Sum of squares	Mean square	Standard deviation	Log of standard deviation
Within lots	44	18,857.18	428.57	20.7	3.029
Between lots	4	9,311.05	2,327.76	48.24	3.875
Total	48	28,168.23	Difference (z)		0.846

[3]Fisher, R. A. Statistical Methods for Research Workers, Ed. 3, Chapt. 8. Edinburgh, London.

D. Since in all cases the material was selected at random, the cause of the greater number of egg tubules in the queens from the laboratory apiary is not known.

VIRGIN QUEEN BEES.—The data in Tables 3, 4, and 5 were taken on virgin queens produced under different conditions with the same mother in some cases and with different mothers in others. In Table 3 lots I, II, and III had the same mother, but they were produced in different colonies and at different times during the year—lot I in late March, lot II in late May, and lot III in mid-September. Lot XX was produced in early October by still a different colony; the mother's ancestry is unknown.

TABLE 3. VARIATION IN NUMBER OF EGG TUBULES IN THE OVARIES OF VIRGIN QUEEN BEES

Number of queens	3		4		3		5		15	
	Number of ovaries									
Number of egg tubules	Lot I		Lot II		Lot III		Lot XX		Total	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
75–85	–	–	–	–	–	–	–	–	–	–
86–95	–	–	–	–	–	–	1	–	1	–
96–105	–	2	–	–	–	–	1	1	1	3
106–115	1	–	–	–	1	1	–	–	2	1
116–125	–	–	3	2	–	–	1	–	4	2
126–135	–	–	–	2	–	2	1	1	1	5
136–145	–	–	1	–	2	–	–	–	3	–
146–155	1	–	–	–	–	–	–	–	1	–
Total	2	2	4	4	3	3	4	2	13	11

A special experimental queen-rearing colony was made up on July 2. Nineteen frames, with sealed and unsealed brood, a few adhering bees, and the pollen and honey in the combs, formed the colony. No other bees were placed in the hive. As a laying queen was not given them, the colony gradually became weaker in bees. Some nectar and pollen was brought into the hive during July and August. By July 7 all the remaining brood was sealed and 6 pounds of adult bees were in the hive. On August 4 there were 5 pounds of bees in the hive. On August 20 a laying worker was present. On September 30 there were 1½ pounds of bees in the hive. At the time of each weighing there probably were some bees in the field.

All the queen bees on which the data in Table 4 were taken had the same mother. Lots V, VI, and VII were reared in the special colony just described. The larvae for lot V were given to the colony on July 8, for lot VI on August 4, and for lot VII on August 20. Lots IV and VIII were reared by different colonies; larvae for lot IV were given to a colony on April 18, and larvae for lot VIII were given to a colony on July 20.

TABLE 4.—VARIATION IN NUMBER OF EGG TUBULES IN THE OVARIES OF VIRGIN QUEEN BEES REARED FROM ONE MOTHER

Number of queens.....	2		10		2		4		6		24	
	Number of ovaries											
	Lot IV		Lot VIII		Lot V		Lot VI		Lot VII		Total	
Number of egg tubules.....	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
75–85.....			2	1							2	1
86–95.....				1								1
96–105.....			2	3		1	1	3			3	7
106–115.....	1		2	3	1		2	1		1	6	5
116–125.....		1	1	1		1			2		3	3
126–135.....	1								2	1	3	1
136–145.....				1					2	3	2	4
146–155.....												
Total.....	2	1	7	10	1	2	3	4	6	5	19	22

The queens on which the data in Table 5 were taken are the progeny of a daughter of the mother of lots IV to VIII, inclusive; that is, they are granddaughters of the mother of the queens in Table 4. This mother of the queens in Table 5 is a hand-mated queen, mated to a drone from her own mother.[4] Lots IX and X were reared in the special colony described above. The larvae in lot IX were given to the colony on September 5, and those in lot X on September 20. A different colony, strong in bees, reared lot XI in July.

TABLE 5. VARIATION IN NUMBER OF EGG TUBULES IN THE OVARIES OF VIRGIN QUEEN BEES REARED FROM THE QUEEN IN TABLE 3

Number of queens.....	10		5		9		24	
	Number of ovaries							
	Lot IX		Lot X		Lot XI		Total	
Number of egg tubules	Right	Left	Right	Left	Right	Left	Right	Left
75–85.....							0	0
86–95.....					3	1	3	1
96–105.....				1	2	2	2	3
106–115.....		1	3	3	1	3	4	7
116–125.....	1	2	2		1	1	4	3
126–135.....	1	3					1	3
136–145.....	1	1					1	1
146–155.....	1						1	
Total.....	4	7	5	4	7	7	16	18

There is a significant variation in the number of egg tubules per ovary for the different lots of virgin queens, if the different lots are considered separately. However, if the progeny of the same mother are combined into one lot, it is found that the mean number of egg tubules for lots II and III is 255.71; for lots VI, VII, and VIII it is 233.12; and for lots IX, X, and XI it is 233.69. The fact that the mother of lots IX, X, and

[4]The hand mating was performed by H. H. Laidlaw.

XI is a daughter of the queen who produced lots VI, VII, and VIII suggests that the number of egg tubules per ovary may be inherited. These results indicate interesting possibilities for a study of inheritance to find out definitely what determines the variation in the number of egg tubules.

DISCUSSION.—Since this work upon the influence of external factors upon the number of egg tubules is preliminary and rather fragmentary at best, no detailed discussion will be attempted. The results recorded in Table 3 show that the different lots of virgin queens have about the same variation in the number of egg tubules, with a slight tendency for the progeny of the same queen (lots I, II, III) to have a greater number of egg tubules. A more pronounced tendency toward variation is seen in Table 4, where all the progeny are from the same mother. Lot VIII shows a smaller number of egg tubules. In Table 5, all from the same mother, lots X and XI tend toward a smaller number of egg tubules.

Owing to the small size of the virgin ovaries used, the counts of virgin egg tubules may not be so accurate as those made upon the laying queens. The counts on the virgins have been included, however, because of the present interest in the controlled mating of queen bees and in the genetics of the honeybee.

Many of the ovaries which were obtained from the virgin queens could not be used because of difficulties encountered in technique. After most of the material had been preserved, it was found that if virgin queens are caged for 2 or 3 weeks their ovaries become nearly as large as those of laying queens, thus allowing accurate counts to be made.

It is interesting to note that the bees in the special colony continued to rear queens, although there were only from 1½ to 2 pounds of bees toward the end of the season and those bees were about two months old.

A U-shaped curve is suggested by the results for lots V, VI, VII, IX, and X in Tables 4 and 5, all reared by the special colony at successive intervals, beginning 18 days after that colony had been made up. The variation in the quantity of material in the different lots, however, precludes exact comparison or the drawing of hard and fast conclusions in respect to changing queen-rearing capacity of the colony as correlated with the age of its workers.

Only five virgin queens are represented in lot X, Table 5. This lot originally contained 15 larvae, 13 of which were accepted when they were given to the special colony more than 11 weeks after that colony had been made up. The queen cells which resulted were small and misshapen. Since lot XI was produced by a colony strong in bees and lots IX and X by from 2 to 3 pounds of old bees, these results indicate that a

strong colony does not cause an increase in the number of egg tubules. It is possible that queens reared by a weak colony will not perform so so well as those produced in a strong colony.

CORRELATION BETWEEN SIZE OF ABDOMEN AND NUMBER OF EGG TUBULES.—Literature on beekeeping contains many references to the belief that in general queen bees possessing large abdomens lay more eggs than queen bees having small abdomens. It is perhaps for this reason that a great deal of emphasis has been placed upon the use of large-bodied queens, but frequently small queens have been observed to produce large colonies. A study was therefore undertaken to determine whether the emphasis placed upon large queens is justified.

Measurements of the length, width, and depth of the abdomens of queen bees were correlated with the total number of egg tubules in the right and left ovaries. There is considerable curvature of the abdomens of queen bees after death, but this curvature is chiefly at the peduncle (the connection between the abdomen and the thorax) rather than in the abdomen itself. Therefore, any error of measurement due to such curvature may be considered negligible. The measurements of the depth and width of the abdomen were made through the third abdominal segment (the second visible segment).

The total number of cases is 41; a larger number is desirable. The abdomens of the 41 queens used ranged from 11.0 to 14.0 millimeters in length, 4.8 to 5.7 millimeters in width, and 4.5 to 5.6 millimeters in depth.

There is a positive correlation between the length of the abdomen and the number of egg tubules. (Table 6.) The result is not statistically "significant," according to Wallace and Snedecor's tables.[5] There is an even smaller correlation between the depth of the abdomen and the number of egg tubules, but a slightly larger one between the width of the abdomen and the number of egg tubules. The regression coefficients show that as the length of the abdomen increases by 1 millimeter the total number of egg tubules can be expected to increase by approximately 7.5; as the depth increases by 1 millimeter the number of tubules can be expected to increase by approximately 14; and as the width increases by 1 millimeter the number of egg tubules can be expected to increase by approximately 20.

The multiple correlation coefficient between the number of egg tubules and the length, depth, and width of the abdomen (rLDW) is 0.341. It is not significant.

[5]Wallace, H. A., and Snedecor, G. W. Correlation and machine calculation, p. 9. Ames, Iowa. 1931.

TABLE 6. STATISTICAL CONSTANTS DETERMINED FROM THE STUDY OF 41 QUEENS

Correlation coefficient		Regression coefficient	
r_{TL}[1] = 0.284		b_{TL} = 7.537	
r_{TD} = 0.141		b_{TD} = 13.859	
r_{TW} = 0.209		b_{TW} = 19.652	
	Mean		Standard deviation
Number of egg tubules	236.09		23.744
Length of abdomen, in mm	12.86		0.893
Depth of abdomen, in mm	5.10		0.246
Width of abdomen, in mm	5.22		0.252

[1]Subscript T = egg tubules, L = length of abdomen in mm, D = depth of abdomen in mm, and W = width of abdomen in mm.

No information is available at this time as to whether a queen with a large abdomen is actually more desirable than a queen with a small abdomen, but this study shows that an increased number of egg tubules tends to be associated with a larger abdomen. It is logical to believe that as the egg tubules increase in number they need greater abdominal space and therefore expand the walls, but the measurements show that the expansion takes place to a greater degree longitudinally than laterally. No doubt the abdominal walls expand laterally with great difficulty, but owing to the elastic tissue which joins the abdominal segments together the abdomen lengthens readily. The ovaries of many queen bees clearly show the outlines of the abdominal segments, indicating that they are under pressure.

SUMMARY.—A study of the number of egg tubules in 73 laying queens procured from several queen breeders showed a variation of from 75 to 175 tubules per ovary. The variation between the different lots is statistically significant.

Virgin queen bees having the same mother varied in the number of egg tubules. The condition of the colony which reared them apparently had little or no effect upon the number of egg tubules.

The simple correlation between number of egg tubules and length of abdomen is 0.284; between number of egg tubules and depth of abdomen is 0.141; between number of egg tubules and width of abdomen is 0.209. The multiple correlation between number of egg tubules and length, depth, and width of abdomen is 0.341. These correlations are not statistically significant.

A PROGRESS REPORT ON THE BEHAVIOR OF THE ALFALFA WEEVIL IN MIDDLE CALIFORNIA, 1935[1]

By A. E. MICHELBACHER and E. O. ESSIG, *University of California, Berkeley*

The finding of the alfalfa weevil in middle California on May 13, 1932, created more than a little excitement. Much concern was occasioned and fear was held that it would spread rapidly throughout the major alfalfa growing sections of the state and do great damage to California's major agricultural crop.

The investigations of this pest were started on June first, 1932, at the time the alfalfa was being cut for the second time and no serious injury to that crop was observed. At that time a survey, conducted to determine the extent of the infestation, showed that the weevil was present over a rather large, discontinuous area, and all indications pointed to the fact that the weevil must have been in middle California several years before it was discovered. These facts indicate that conditions in the newly infested area were not specially conducive to rapid increase of the insect or it probably would have been noted earlier.

Population studies were conducted in several fields at Pleasanton and Niles. At the former location the greatest numbers of adults and larvae occurred on the second crop, while at Niles they were found most abundant on later cuttings. Of course, it was impossible to tell what had occurred on the first cutting, and the lack of such information was a marked handicap in carrying out the 1932 investigations. However, the information obtained seemed to show that the climatic conditions around Niles were more favorable for the development of the weevil than those at Pleasanton. Large numbers of larvae were collected at Niles during July and August, while at Pleasanton the larvae were never taken in large numbers during these two months. It seemed that the cooler summer temperatures of the former permitted much greater development of the weevil there, than at the latter where much warmer conditions prevailed. If this is true, then the activity of the weevil would be expected to be even more restricted in the San Joaquin Valley. In order to gather further information on this particular phase of the subject we extended our investigations of the past season into the Tracy and Vernalis areas of that valley. It should be pointed out that these two places are cooler than many locations in the valley, due to the moderating influence of the ocean winds which pass up the valley from the San Francisco Bay.

Our 1932 investigations led us to believe that the alfalfa weevil in general would not be very destructive under the lowland conditions

[1]This article should have preceded the "Report on Alfalfa Weevil Investigations in Middle California" which appeared in the October issue.

in California. It was recognized, however, that the activities of the insect had been studied for such a short period here that it would be very dangerous to draw any definite conclusions. Undoubtedly its biology must be studied for several years before a great deal can be ascertained for a certainty regarding its responses under the varied climatic conditions in which it now occurs.

The populations encountered during 1933 were considerably greater than were anticipated. In the Pleasanton area counts of more than 6000 larvae to 100 sweeps of an insect net occurred, while in the region about Niles larval counts up to 1700 were made. In the Tracy region larval counts averaging only about 500 were obtained. In both the Pleasanton and Tracy areas the greatest number of larvae occurred on the first cutting. This was also partly true of the Niles territory, but in two fields under observation, the highest counts occurred on the third crop.

While counts of from 5000 to 6000 were not uncommon in the country about Pleasanton, such populations were present only in neglected fields. If these fields had received better cultural treatment, such numbers undoubtedly would have been reduced considerably. The alfalfa could have been cut earlier in several cases, and by so doing injury could have been reduced to a marked degree. For example, one field was ready to be cut about the 16th of April, and at this time the larval count ranged from 1300 to 2000 per 100 sweeps, while just previous to that date the count had been less than 1000. However, the field was not cut until April 28th when the larval count mounted to from 4000 to 5000 per 100 sweeps. Not only did the alfalfa suffer from weevil injury, but before it was cut it was hurt considerably by drought. In this field, and others, no irrigation was given following the removal of the first crop, and, despite this, a fairly satisfactory second crop was obtained. These fields were badly neglected because of depressed economic conditions and it is quite likely, but not certain, that under normal times such neglect and high larval counts would not be expected. This belief is strengthened by the fact that in the better tended fields counts of only 1000 or less were obtained. It therefore seems that in this area proper winter culture, along with cutting and irrigating at the correct time, will materially aid in reducing the numbers of the weevil. In this territory the weevil population fell off rapidly after the removal of the first crop and there was some slight building up of populations on succeeding crops, with the exception of the moderate numbers of the second cutting.

Table 1 summarizes the data obtained from the fields at Pleasanton during the 1933 growing season. It gives the highest larval and adult counts observed for each cutting, together with the care the fields re-

ceived. Throughout the district there were other fields which were as well cared for as those classed as good in Table 1 and where the larval counts for later cuttings were higher. These counts, however, rarely exceeded 25.

TABLE 1. WEEVIL POPULATIONS IN RELATION TO CARE OF ALFALFA

Care of field	1st cutting		2nd cutting		3rd cutting		4th cutting		5th cutting	
	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed
good...	1008	8	390	69	83	12	9	7	12	14
good...	607	13	478	53	37	8	5	5	15	13
very poor..	6432	26	1180	187	field completely neglected					
poor....	4461	51	939	205	field completely neglected when cut 2nd time, alfalfa was very dry and short					

At Niles the behavior of the weevil was markedly different. Slight injury occurred in at least one field where the cultural care could be classed as good. However, in the case of this field no population counts were made while the first crop was growing so it is impossible to give any idea of the numbers present. In the fields studied the counts per 100 sweeps ranged from less than 1000 to something over 1700 in well cared for fields. In these fields little damage was noticeable and, one field was cut early, not on account of any damage done by the alfalfa weevil, but because of a severe infestation of the pea aphis.

Throughout the entire growing season larvae could be collected with great ease and on some of the crops they became quite abundant. The only explanation for this seems to be that the climate of this region is very favorable for weevil development. The mild winters followed by the cool summers seem to favor the insect to a very high degree. Even though the past season (winter and early spring) was somewhat colder than normal, weevil development was well under way by the first of March. On March 3rd an average of 171 larvae were collected to the 100 sweeps and as late as the 8th of December, larvae were collected with considerable ease in fields which showed a small amount of growth. In one of the fields under observation 16 larvae were taken to the 100 sweeps, although at the time the field was being pastured to cattle.

It seems that under the climatic conditions as they exist in this territory, the weevil may at times become injurious, although if the alfalfa receives suitable care it will probably outgrow the injury. It may be that the mild climate has also a controlling effect upon the pest. The weevil is supposed to be single-brooded, but under the conditions as they

exist in this climatic zone, the brood is probably much diffused. The fact that high peaks of population are reached in March and July would indicate that there are groups of weevils reaching maturity from time to time, or it might be that the weevils which develop early in the season reach sexual maturity by mid-summer and thus give rise to a partial second generation of considerable size. Snow[1] carried on an investigation in which he showed that it takes about four months at least for adult weevils to reach sexual maturity, and even with a period as long as this it is likely a fair number of weevils reach the egg-laying stage during July and August. During the past winter newly-emerged adults with soft elytra were taken as early as March 24th. At any rate there are several peaks, and this fact is probably important in preventing a concentrated attacked by the weevil on the alfalfa at any one time. Certainly where alfalfa is growing under the best conditions a rather large population in mid-summer is not as likely to do as much damage as a similar number of weevils earlier, when the alfalfa is growing much slower. This actually seems to be the case, for no injury was noticeable in fields where 1000 or more larvae were collected to the 100 sweeps during July.

Table 2 summarizes the data for fields under observation in the Niles region. It gives the location of the fields, number of cuttings, and the greatest numbers of larva and adults observed per 100 sweeps. A glance at the table shows that the larvae were rather abundant throughout the entire season, a particular characteristic of the Niles area.

The behavior of the weevil in the Tracy area seems to be different from that in the two areas previously discussed. The highest larval counts occurred on the first cutting, but in general were much lower than those found on the first cutting in either of the regions about Niles or Pleasanton. This was true despite the fact that the fields selected seemed to have as high larval populations as any fields to be found in this particular area. From a limited survey the weevil seemed to be rather scarce in most fields. The reason for this is not fully known. The very limited numbers of the weevil in certain fields scattered throughout this large Tracy region seem hardly accountable to recent introductions into these particular fields. However, another season of study should throw some light on this question.

In one field near Vernalis the weevils (both larvae and adults) were able to maintain themselves in a fairly satisfactory manner. That is, they could be collected with considerable ease throughout the entire

[1]Snow, S. J. Effect of ovulation upon the seasonal history in the alfalfa weevil. Jour. Econ. Ent. vol. 21, pp. 752–761, 1928.

TABLE 2. LARVAL AND ADULT COUNTS BY CUTTINGS

Location	1st cutting		2nd cutting		3rd cutting		4th cutting		5th cutting		Taken from growth following last cutting	
	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed
Irvington	944	17	340	60	1,374	20	58	6	200	5	20	1
Centerville	156	2	46	7	204	7	41	25	No 5th cutting		4	0
Niles	1,761	3	144	52			Farmer objected to further use of field					

growing season. This condition differed from the other two fields in which population studies were made. One of the latter was located only a few miles away, and in this the larvae and adults were extremely scarce throughout the whole season. The other field was located near Tracy and, while this field showed a fairly high count early in the season, the weevil became very scarce on the 4th crop and practically disappeared after that.

Unquestionably the care which the fields receive has some influence upon the weevil. Why should the field at Vernalis show a fair population throughout the season when a field only a few miles away showed almost a complete absence of the pest, when both of these fields were known to be infested in 1932? Each of these fields received good cultural care, and the difference in populations is very puzzling. It may be that the nature of the soil, or the method of applying irrigation water is important. Both of these fields received at times two applications of irrigation water to a single cutting. This practice obviously has a modifying effect upon the field temperatures and in the case of the field having the higher population, these changes may have been very favorable for the weevil. When a single crop is irrigated twice the soil at cutting time is apt to be moist and the temperature next to the ground is reduced many degrees, which favors the survival of the weevil as shown in Table 3. It may be that such a practice of irrigating will allow the weevil to penetrate into parts of the hot dry valleys where heat would otherwise restrict its activity. Of course under such conditions the weevil would not be expected to do much if any damage.

The field near Tracy is located on low lying land which apparently also receives some sub-irrigation. It was irrigated only twice, once in May and again at the end of July. By the end of summer it became very dry and this may have been responsible in part for the weevil population falling off so decidedly. Better hay and at least one more crop could have been obtained if this field had been properly irrigated after each cutting.

Table 4 gives a summary of the data collected for the above mentioned fields. The location of the fields, the number of cuttings, and the peak larval and adult counts observed per 100 sweeps are shown.

Under the climatic conditions of middle California at least six cuttings of hay can be expected throughout a season if the fields are properly tended and the alfalfa is cut when ready. This is in marked contrast with the Great Basin where the expected number of cuttings does not exceed three. Undoubtedly the numerous cuttings which occur under the California environment have a tendency to check the destructiveness of the weevil by subjecting the insects to temperature and cultural

kill. While in the mountain states the weevils are exposed to destruction by cutting only two or three times throughout the season, here in California they are exposed to similar severe conditions 5 or 6 times. However, when alfalfa is cut for the first time, which is during the first part of April, the prevailing temperatures may be low and cultural kill considerably reduced.

TABLE 3. TEMPERATURES AT SOIL SURFACE IN ALFALFA FIELD FOLLOWING CUTTING AND REMOVAL OF HAY WHERE THE CROP RECEIVED TWO IRRIGATIONS.
(Second Irrigation Given One Week Prior to Cutting).

Time	Air Temp.* °F.	°F Dry edge of field		°F Dry spot in field		°F Moist spot in field	
	Four feet above soil surface	Mercury bulb covered with dust	Mercury bulb exposed on soil surface	Mercury bulb covered with dust	Mercury bulb exposed on soil surface	Mercury bulb covered with dust	Mercury bulb exposed on soil surface
11:50.....	88	127	118.5	122	121	104	105
12:20.....	89.5	132	122	125	123	109.5	107
1:00.....	91.5	135.5	125.5	125.5	124	113	109

*Maximum summer temperatures for this area may vary from 102°F to 108°F. Day clear, moderate breeze.

It is also interesting to note that higher maximum temperatures can be expected in the weevil infested region of middle California than in the Great Basin. The only exception is in the Niles area where the maximum expected temperatures are much lower than those which occur further inland. The hot dry summers with the numerous cuttings must very adversely affect many of the weevils which reach the adult stage early in the season and must contend with the long hot summer and fall.

Certainly, the weevil behaves differently in the three areas discussed in this paper, and at a later time a thorough study of the insect in relation to the different climatic zones will be made. At the present time it is our belief, and evidence seems to point to the fact, that high temperatures coupled with the extreme dryness of the interior valleys will act as a satisfactory check on the weevil.

During the past season the United States Department of Agriculture, Bureau of Entomology, alone, and in cooperation with the University of California Experiment Station, introduced parasites of the alfalfa weevil into infested fields at Pleasanton, Tracy, and Niles. The influence of these parasites on the weevil is still unknown, and the number of species which will finally become established still remains to be seen.

Birds may be of some importance in controlling the pest. Blackbirds, meadow larks, and others are often fairly abundant in the infested fields. Blackbirds are sometimes present in large numbers while the fields are being irrigated, and on such occasions they must consume many weevils.

TABLE 4. LARVAL AND ADULT COUNTS BY CUTTINGS—1933

Location	1st cutting		2nd cutting		3rd cutting		4th cutting		5th cutting		6th cutting		Collected following last cutting	
	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed	highest larval count observed	highest adult count observed
Tracy	499	2	22	20	18	9	4	0	0	7	No 6th crop		0	0
Vernalis	642	8	88	94	66	17	72	9	11	7	7	16	2	1
Vernalis	5	0	7	2	1	1	16	2	1	0	1	2	0	0

Inasmuch as the fields are irrigated 3 to 5 times or more these birds have an excellent opportunity to feed on the pest and probably reduce its numbers considerably. This we suspect is particularly true when stubble fields are being irrigated.

On several occasions the adult weevils have been noted to be stimulated to great activity. As the investigation advances it appears to us that flight may be one of the most, if not the most, important natural factor in the spread of the weevil. No general flight movement of the insect has been noted, but weevils have been observed to fly many times. They seemed to be most active on warm days in the fall, late winter, and spring through June.

Throughout the growing season weevils were gathered at random from time to time to see whether egg deposition was occurring. No attempt was made to separate the old and new generations. From all groups collected some eggs were obtained. Egg-laying probably continues throughout the winter to a small extent. In field cages at Pleasanton on January 6th and 13th, 1933, several batches of eggs were observed in stems of alfalfa which had been severely injured by frost. The eggs for the most part were rather bright in color which would seem to indicate that they were newly laid.

In another field cage evidence was obtained which seemed to show that the weevil can pass through the winter in the pupal stage. Late in the fall of 1932 a large number of larvae were placed in a cage. Some of these pupated and emerged, but several examinations between January 6th and February 10th revealed a number of live and dead pupae. Whether or not adults ever emerged from the live pupae is not known but it appears that some managed to come through since many adults were subsequently present in the cage.

Under natural conditions the weevil has been found breeding on four different hosts. These are: alfalfa, bur clover, yellow sweet clover, and white sweet clover. The importance of these hosts is in the order given. During the past season the weevil was found with great ease on bur clover, and yellow sweet clover throughout Niles Canyon from Pleasanton to Niles. A careful examination showed it also present on white sweet clover, although on this host it was rather difficult to find. We are satisfied that the first two are important natural hosts in maintaining the insect outside of alfalfa fields and may materially aid in its natural distribution. Both of these plants appear with the first fall and winter rains and afford ready food for the weevil until early summer.

INEFFECTIVENESS OF SURFACE CULTIVATION TO PREVENT THE BURROWING OF PECAN WEEVIL LARVAE INTO THE SOIL UNDER PECAN TREES

By THEO. L. BISSELL, *Division of Fruit and Shade Tree Insects, U. S. Bureau of Entomology*[1], *Experiment, Ga.*

In a series of small-plot experiments reported by the writer in 1931[2] larvae of the pecan weevil (*Curculio caryae* Horn) were largely prevented from burrowing into soil that was cleared of vegetation, leveled and rolled. However, experiments conducted in 1932 in pecan orchards and herein reported failed to substantiate the results of the former study.

Weevil-infested pecan trees were selected in two orchards, as follows: ten trees of the Stuart variety at Experiment, Georgia, growing on Cecil clay loam, and seven Schleys and one Stuart at Milner, Georgia, growing on Cecil sandy loam. Shortly before the period of larval emergence from the pecan nuts the ground occupying half the area under each tree was hoed and hand-raked to remove all vegetation, stones, and other debris and to form a smooth, even surface. The ground was broken to a depth of 1 to 2 inches. At Experiment the plots were also packed with a roller weighing 260 pounds. The ground occupying the other half of the area under each tree was not touched. It was covered rather thickly with grass, weeds, and dead plant material, and in the orchard at Experiment was quite rough, having been plowed several months before the experiments were begun but not harrowed. The treated areas were alternated between north and south sides of successive trees.

After the pecan weevil larvae had left the nuts on the trees the numbers that had burrowed were obtained by digging and sifting the soil from six plots under each tree, three from treated and three from the untreated ground. Each plot was 1 yard square and was dug to a depth of 9 inches. This work was begun in November after harvest and was completed in February, 1933.

Life history studies have shown that two or more winters are passed in the soil by the pecan weevil, therefore of the numbers dug some were expected to be from broods of former years. These would include all the adults and probably some of the larvae. In the Milner orchard, diggings had been made in June 1932 to determine the insect population of the soil. The orchard consisted of 200 trees, and 99 plots, each 2 feet square, were dug under alternate trees. From the 44 square yards of soil six

[1] In cooperation with the Georgia Agricultural Experiment Station, Experiment, Ga.

[2] Jour. Econ. Ent. 24 : 861–866. 1931.

larvae of *C. caryae* were taken, not more than one larva from any one plot. This shows that there were comparatively few larvae in the soil at this place when the experiment was begun.

The population of the soil at Experiment was not determined before the tests were begun, but as there was a low infestation of pecan nuts in this orchard in 1931, it is assumed that there were few larvae in the ground before the advent of the new brood of 1932.

At Experiment there was a second source of error in the work in that the plots were not prepared until after emergence of larvae had begun. The ground was treated on October 6 and 7, and from 300 infested nuts collected on October 8, nine per cent of the larvae had already issued. However, there was no evidence that this early emergence affected the results appreciably.

TABLE 1. PECAN WEEVIL LARVAE EMERGING FROM NUTS AND DUG FROM SOIL AT EXPERIMENT, GA., 1932

Tree No.	Diameter of tree spread	Area of tree spread	Larvae emerging		Larvae dug in 6 sq. yrds.		
			Total	Per sq. yd.	Treated soil	Untreated soil	Per sq. yd.
	Feet	*Sq. yds.*	*Number*	*Number*	*Number*	*Number*	*Number*
1	32	89.0	623	7.0	13	26[a]	6.5
2	31	84.0	301	3.4	18[a]	3	3.5
3	29	73.0	221	3.0	4	5	1.5
4	28	68.0	524	7.7	19	19	6.3
5	30	78.5	612	7.8	16	13	4.8
6	33	95.0	729	7.7	26	19	7.5
7	35	107.0	660	6.2	19	20[b]	6.5
8	28	68.0	1185	17.4	26	45	11.8
9	27	64.0	230	3.6	5[a]	5	1.7
10	24	50.0	253	5.0	7	1	1.3
Total.....		776.5	5352	6.9	153[b]	156[c]	5.1

[a]And 1 adult [b]And 2 adults [c]And 3 adults

The number of larvae that left the infested nuts on each tree to burrow into the soil is shown in Tables 1 and 2. This number was determined by counting the harvested nuts having holes made by issuing larvae and multiplying the total by the average number of larvae leaving one nut. This average, 2.3 larvae for Stuart and 2.5 for Schley pecan nuts, was determined from collections over a period of several years. It will be noted that the number of larvae developing in the nuts on each tree, for each square yard of surface covered by the branches, corresponds roughly with the number per square yard dug under each tree, from treated and untreated ground. For the ten trees at Experiment an average of 6.9 larvae per square yard emerged from the nuts and 5.1 larvae were dug. At Milner the emergence was 4.9 and the average number dug

was 2.9. These numbers further indicate that there were few larvae in the soil before the experiment was started.

TABLE 2. PECAN WEEVIL LARVAE EMERGING FROM NUTS AND DUG FROM SOIL AT MILNER, GA., 1932

Tree No.	Diameter of tree spread	Area of tree spread	Larvae emerging		Larvae dug in 6 sq. yds.		
			Total	Per sq. yd.	Treated soil	Untreated soil	Per sq. yd.
	Feet	*Sq. yds.*	*Number*	*Number*	*Number*	*Number*	*Number*
1	20	35.0	57	1.6	0	1	0.25[b]
2	30	78.5	45	0.6	3	0	0.50
3	20	35.0	72	2.0	9	1	1.70
4	30	78.5	692	8.8	20	31	8.50
5	32	89.0	1310	14.7	32[a]	25	9.50
6	30	78.5	87	1.1	2	12	2.30
7	34	101.0	188	1.9	3	0	0.50
8	18	28.0	113	4.0	1	0	0.17
Total.....		523.5	2565	4.9	70[a]	70	2.93

[a]And 2 adults. [b]Only 4 square yards dug under this tree.

RESULTS AND DISCUSSION.—Practically the same number of larvae entered the treated and untreated soils. At Experiment (Table 1) 153 larvae were taken from the treated plots and 156 from the untreated, while at Milner (Table 2) 70 larvae each were found in the treated and untreated soils.

The failure of these experiments to show positive results, as compared with the earlier work, was possibly due to the heavier rainfall that occurred in 1932. At Milner there were over 3 inches of rain during the first part of the emergence period and immediately following the preparation of the plots. On October 15 and 16, when about half of the larvae had emerged, 5.4 inches of rain fell at Milner and there were additional rains on October 31 and November 8. At Experiment, following the treatment of the soil plots, 4.75 inches of rain fell on October 15 and 16 and there were more rains October 23 and 28. The writer has previously stated: "Rain apparently helped larvae to burrow by softening the ground and by reducing the temperature of the soil surface."[3]

Another factor that may have influenced the numbers of larvae burrowing was the accumulation of leaves on the plots in 1932 as leaves retard the drying of the surface and afford burrowing places for larvae.

From the results obtained in this study it is concluded that cleaning and smoothing of the surface of soil under pecan trees cannot be depended upon to control pecan weevil larvae in all years.

[3]*Ibid.*

CALCIUM CARBONATE AS A WEEVIL CONTROL

By DR. E. R. DE ONG, *Consulting Entomologist, San Francisco, California*

Rice is especially subject to insect injury in the warehouse because of the lateness of harvest. Grain threshed in the fall must supply the trade until the harvest of the following year. The long exposure in the warehouse during warm weather gives abundant opportunity for weevil injury, especially with the large carry-overs of recent years. Control of such injury, if considered at all, is principally by fumigation. Now it has been found that the small amount of calcium carbonate used during milling is in itself a good insecticidal practice.

The Japanese trade has always demanded a calcium treated rice as being superior in flavor to untreated rice, such treatment being common in the Orient. This practice was probably developed through the use of calcium carbonate in milling to prevent the development of heat by friction which results in a lost flavor. The custom is now so common that the very slight flavor given by the calcium is considered so desirable that rice lacking such a flavor is rated as inferior.

The author is working with the Commercial Minerals Company of San Francisco on the use of a specially prepared calcium carbonate and imported talc, which material this Company has long supplied the California rice trade for coating purposes. During the investigation it was found that calcium carbonate was not only of value in retaining the rice flavor but in addition had the surprising value of protecting the rice against weevil injury. The investigation on the protection against insect injury included two forms that are common in the warehouse, the rice weevil (*Sitophilus oryzae*) and the bran bug (*Tribolium confusum*). In a jar of uncoated rice, 17 rice weevil and 10 bran bugs were placed alive on November 20, 1932. In a similar jar, containing rice coated with one per cent by weight of calcium carbonate, 22 rice weevil and 13 bran bugs were placed on the same date. These jars were kept in an unheated room where the temperature ranged from 50° to 75° F., the only attention given being to occasionally add a few drops of water so as to make possible breeding whenever the temperature was sufficiently high. On the 20th of January, 1933, the uncoated rice showed 4 dead rice weevil, 4 dead bran bugs and 13 living weevil and 5 living bran bugs. The coated rice showed the following count: 11 dead rice weevil and 9 alive; 6 dead bran bugs and 7 alive. A second count was made on the 31st of October, 1933, almost a year following the beginning of the experiment. At this time the uncoated rice contained 2 dead rice weevil and 175 living weevil. No dead bran bugs could be identified, they apparently having been

broken up in handling the rice as but 2 living bugs were found. In the coated rice there were 5 dead weevil and 22 living ones. No dead bran bugs were found, but 1 living one.

It will be noted that in 60 days at winter temperature, where cold checked breeding, the rice weevil had decreased 50% in the coated rice, and in the uncoated rice 23%. The striking results of the experiment came, however, at the end of the year and following the higher summer temperatures which had permitted breeding. At this time it was found that the weevil in the coated rice had remained absolutely stationary, that is, there had been just sufficient breeding to take care of the small number dying. But in the uncoated rice we have the remarkable increase of more than 1000%, namely from 17 to 175. The loss in weight resulting from the weevil attack amounted to 42%, a cubic foot of the coated rice weighing 76 pounds, and the uncoated rice 44 pounds.

The results of the experiment confirm the theory that the very small amount of calcium carbonate used is a satisfactory protection against weevil injury. The value of the treatment includes not only the avoidance of weight loss but the need of recleaning and a possible loss of one or more grade points. Also, as mentioned, certain trades actually prefer rice having the slight flavor imparted by calcium carbonate. In addition to milling stocks, this principle might be applied to stored seed grain as a protection against rough bodied insects, such as the rice and grain weevil.

RELATION OF AIR AND BARK TEMPERATURES OF INFESTED PONDEROSA PINES DURING SUBZERO WEATHER

By J. A. Beal, *U. S. Bureau of Entomology, Portland, Oregon*

It is a well established fact that unusually low winter temperatures are sometimes responsible for the death of many hibernating bark beetles. The first published observations of the effect of cold weather on overwintering bark-beetle broods, especially of the southern pine beetle (*Dendroctonus frontalis* Zimm.), were published by Hopkins (3) in 1899, although he later attributed the mortality in part to disease.

In 1924, following minimum temperatures of −20° to −25° Fahrenheit, A. J. Jaenicke of the Forest Service found heavy mortality among broods of the western pine beetle (*Dendroctonus brevicomis* Lec.) on the Metolius area near Bend, Oregon.

During the winter of 1926–27, at Asheville, N. C., the writer (1 and 2) found that general and heavy mortality of the southern pine beetle oc-

curred during unusually cold periods when the temperature fell to 10°, 2°, and −5°F.

A series of laboratory tests were conducted at Stanford University from 1926 to 1929 by Miller (4, 5) to determine the low lethal temperatures for different brood stages of the western pine beetle. The material used consisted for the most part of infested ponderosa pine bark containing advanced brood stages, which was removed from the tree and subjected to controlled temperatures in laboratory apparatus.

Further evidence (6) of the effect of low temperatures in reducing overwintering broods of the western pine beetle was obtained during an unusually cold period in December 1932 in parts of Oregon, Washington, and California, by the U. S. Bureau of Entomology through its stations located at Berkeley, Calif., and Portland, Oregon.

Since bark beetles hibernating within and beneath the bark of trees are given considerable protection from extreme low temperature, it became desirable to determine the difference between bark and air temperatures during critical periods.

In January 1927 and again in January 1928, at Coeur d'Alene, Idaho, J. C. Evenden and H. J. Rust (5) placed thermometers in the bark on the north and south sides of a standing ponderosa pine tree, suspended thermometers in the air, and took hourly readings over a period of 28 hours. The lowest air temperature recorded was −6° F., when the corresponding bark temperatures were 4° and 6° F.

Further records of air and bark temperatures in the field during extremely low temperatures were essential for the purpose of determining the expectancy of mortality for broods of the western pine beetle as a result of winter freezing. Accordingly a series of records of subcortical and air temperatures were obtained in the field in 1933 on the Ochoco National Forest in Oregon during the coldest period of the winter. An analysis of the bark and air temperatures thus obtained is presented in this paper.

PROCEDURE, MATERIALS, AND METHODS.—Early in February the local Weather Bureau office reported that subzero temperatures were predicted within the next 36 hours for eastern Oregon. Accordingly thermometers and thermographs were immediately packed and a hurried trip was made by the writer and W. J. Buckhorn, scientific aid, to the Ochoco National Forest in order to record the air and subsequent bark temperatures reached during the cold period.

Standard mercury Fahrenheit thermometers were placed beneath the bark of six infested ponderosa pine trees of different bark thicknesses. Three of these were summer-brood trees and three were winter-brood

trees. The thermometers were placed on both north and south sides of the trees. Similar thermometers were suspended from two of the trees and kept in the shade. Likewise recording maximum and minimum thermometers were inserted in the bark on the north and south sides of six additional infested ponderosa pine trees and a maximum-minimum thermometer was suspended from the north side of one of them. Two thermographs were installed, one at the Ochoco Ranger Station and one near the trees, a half mile from the station, and mercury thermometers suspended near them.

Hourly readings were made on all except maximum and minimum thermometers and these were read daily. Continuous records were taken over a period of 66 hours until the cold weather had largely subsided. Subzero temperatures prevailed over about 24 hours of this period.

At the end of the cold period infested bark samples were taken from both sides of a number of the trees used in the tests and brought into the laboratory and analyzed for brood mortality. Bark thickness, size of tree, side of tree, exposure, character of bark, and age of brood were carefully recorded for final comparison. Also brood which died during an earlier freeze in December (6) was separated in the final analysis from that which died as a result of the February freeze.

DATA OBTAINED.—An examination of air temperatures recorded during the 66-hour period showed that there were no wide or constant differences in air temperature at any of the stations used. Air temperatures at the Ranger Station, as well as in the woods, were always within a degree or two of each other. The highest recorded air temperature was 25° and the lowest −26° F.

An analysis of subcortical temperatures, as expressed in Graphs I and II, shows that in bark one-half inch in thickness high temperatures of about 25° F. were recorded and low temperatures of −17° and −18° F. were reached. Bark 1 inch in thickness reached about the same maximum temperatures but dropped to a minimum of only −5° to −8°. Thicker bark, 1⅛ and 1½ inches in thickness, showed a similar maximum of 25° but minimums of −4° and + 1°, respectively. Still thicker bark, 1¾ and 2 inches in thickness, also showed similar high readings but gave low readings of only zero and + 3°, respectively. Thus the importance of bark thickness in regulating subcortical temperatures can readily be seen.

A thermometer inserted into the center of one of the trees used in the test varied but little. During variations in air temperature from −4° to + 17° this thermometer registered 6° and 7°, a change of only 1 degree.

The maximum-minimum recording thermometers which were in-

serted beneath the bark on six of the trees were found to give slightly inaccurate readings. These thermometers were built for the Forest Service for use in the soil, and the exposure of the unusually long shanks resulted in slightly lower minimum readings and higher maximum readings than actually occurred in the bark. Because of this discrepancy the temperatures obtained by these thermometers were omitted from the results given in this paper.

ANALYSIS OF FINDINGS AND DISCUSSION.—During the course of the work it was apparent that there was considerable variation in bark temperatures on the north and south sides of the same tree. The south side of the tree warms up rapidly for a short period during the day when the sun is shining directly on the bark. Heat is then absorbed rapidly and subcortical temperatures rise much higher than those on the north side of the tree. On bright days the sun was found to warm up the south sides of the trees chiefly from about 10 a. m. to 3 p. m. When shadows of other trees interfered, as they frequently did, subcortical temperatures dropped very rapidly. Although the south side of some trees warmed up during the day to as much as 16 degrees above air temperature, they dropped again during the night as low as subcortical temperatures on the north side of similar trees.

Apparently the reflection of the sun on the snow had an immediate effect in raising bark temperatures. At 9 o'clock on the second day the sun shone brightly and all temperatures started rising. On the north side of the trees subcortical temperatures increased rapidly, even though air temperatures remained far below them. Probably this is due in part to the effect of reflected heat from the sunlight on the snow.

Bark thickness is by far the most important single factor which determines the relation of air temperature to subcortical temperature of trees in the field. A study of the accompanying graphs (I and II) shows that temperatures in thin-bark trees correspond closely to air temperatures. The bark of thin-bark trees cools rapidly with falling air temperatures and warms up quickly as temperatures rise. The bark in thick-bark trees responds more slowly to changes in air temperature and it requires periods of cold of long duration or excessive cold to reach fatal temperatures.

A sharp change in the trend of air temperature produces a corresponding change in subcortical temperatures. An examination of the graph shows that there is a lag in bark temperatures on thin-bark trees of about one hour behind air temperature (see also Table 1). In thick-bark trees the time of this lag is increased to about two hours. Intermediate bark thicknesses show corresponding lags.

The spread between bark and air temperatures is not constant even with bark of equal thickness. When air temperature remains at a constant level for a day or more, bark temperatures tend to reach this level. When air temperatures drop suddenly there is a spread between air and bark temperatures which increases with acceleration of the drop in air temperature and also increases with the bark thickness. As temperatures rise again this spread rapidly disappears until bark and air temperatures are equal, and then the spread continues in the other direction until air temperatures again drop.

TABLE 1. LAG AND SPREAD IN AIR AND BARK TEMPERATURES ACCORDING TO BARK THICKNESS

Bark thickness	Air temperature	Spread between air and bark temp.	Lag of bark behind air change
Inches	*°F.*	*Degrees*	*Hours*
½	—26	8	1
⅝ to 1	—26	18 to 21	1
1⅛ to 1½	—26	22 to 27	2
1⅝ to 2	—26	26 to 29	2

Miller (5), working on low temperatures lethal to the western pine beetle, found that under laboratory conditions mortality of the larvae followed freezing when bark temperatures were lowered below 0° F. He found that partial mortality occurred at zero in broods which overwinter in the ponderosa pine belt of the Sierra Nevada region; that mortality at −5° exceeded 60 per cent, and that practically no larvae survived at −10° F. He also found that broods obtained from regions where minimum winter temperatures are often below zero apparently have acquired a greater resistance to cold than those from regions with mild winter climates.

Analyses of a limited number of bark samples which reached known temperatures under field conditions on the Ochoco National Forest, Oregon, show a higher percentage of survival at low temperatures (Table 2) than Miller obtained in his freezing tests. In field tests a survival of 27.6 per cent was found at −17° F. This difference is probably due to one or a combination of several things; first, broods from eastern Oregon are probably more cold resistant than those from North Fork, California; second, temperatures in the field reached their low point for only a very brief period while in the laboratory they remained near the low point for three or four hours; third, there may have been other differences between the laboratory and field tests; fourth, the difference in observed mortality may be due to the fact that a previous freeze had already killed about 50 per cent of the brood and the remaining larvae may have been principally the hardier individuals.

TABLE 2. MORTALITY OF WESTERN PINE BEETLE LARVAE SUBJECTED TO 26 DEGREES F. BELOW ZERO UNDER FIELD CONDITIONS[1]

Bark thickness	Subcortical temperature	Larvae		Mortality
		Living	Dead	
Inches	*°F.*			*Per cent*
½	—17	26	69	72.4
¾	—14	40	72	64.0
¾	—11	24	30	55.5
1–⅛	— 5	71	68	48.9
1–¼	0	170	86	33.5

[1]Examinations made 8 days after the cold period.

In general it can be said that when air temperatures reach 0° F. some mortality of western pine beetle broods occurs. Mortality increases with decreased air temperatures, but depends largely upon the amount of protection afforded by the bark. Because bark does not cool down as rapidly as the air, there is often a margin of safety, during extremely cold periods, which enables a portion of the overwintering broods to survive even the most severe cold attained. It is this margin of protection, coupled with the probably ability of those of the more northern range to endure more intense cold, that enables the species to retain its foothold in the northernmost extent of its range.

By projecting the curves in graphs I and II, which depict decreasing bark and air temperatures, it would appear that air temperatures of —50° to —60° F. would probably be required to give bark temperatures of —20° to —25° fatal to all the broods even in bark 2 inches thick. Such low temperatures rarely if ever occur in the transition zone of this region.

The graphs also indicate that the low temperatures obtained during this period would have to be continued for at least 24 hours to bring thick bark down to fatally low temperatures, and there is the possibility that the rate of fall of bark temperatures would slacken if air temperatures remained constant. This is a point upon which additional information should be obtained.

SUMMARY.—Low winter temperatures are sometimes very important in the natural control of the western pine beetle (*Dendroctonus brevicomis* Lec.). Since the cold must reach the insects through the protective covering of the outer bark, the thickness of this layer is of vital importance. The thicker the bark, the better the protection.

Hourly records of air and inner bark temperatures on infested standing ponderosa pine trees during a period of rapidly falling temperatures showed that when the air reached a temperature as low as —26° F. for a short time only, the subcortical temperature in trees ranged from 8 to 29 degrees higher. These differences in subcortical temperatures are due

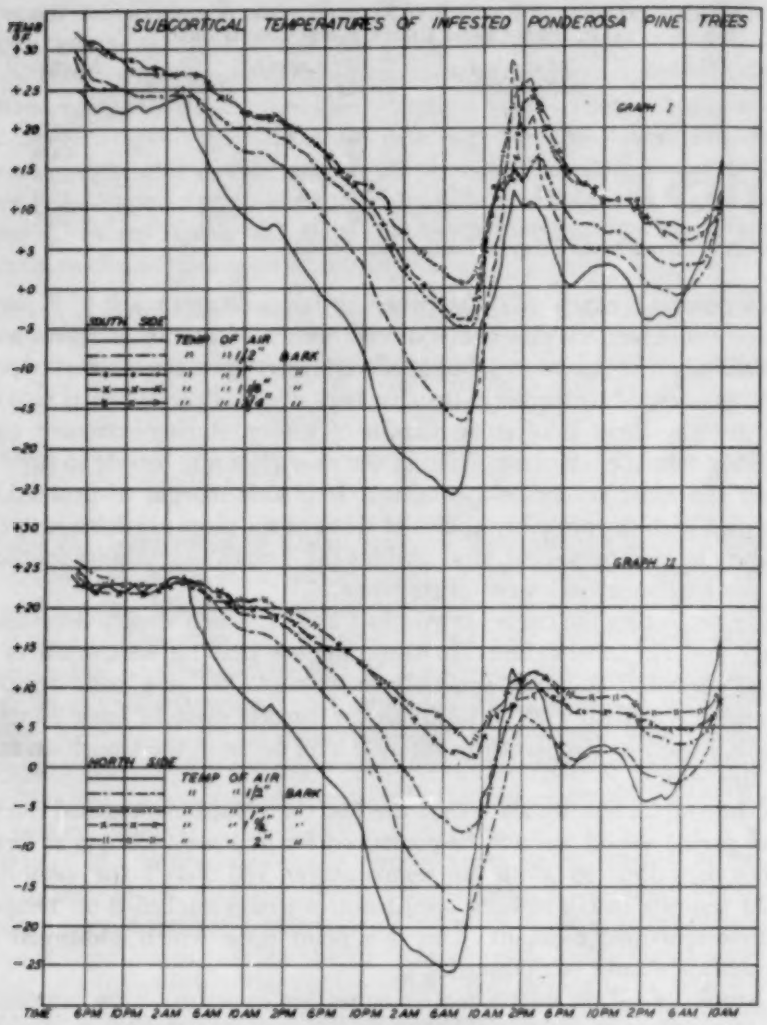

FIG. 138.—Graphs showing air and bark temperatures.

largely to the thickness of the bark. Thin bark closely follows the trend of air temperatures, while thicker bark responds more slowly and requires either long duration or excessive cold to reach temperatures fatal to the brood.

Temperature variations according to side of tree are not believed to be very important. For a brief period during the middle of sunny days the south side warms up more than the shaded portion, but bark temper-

atures rapidly fall again during the night so that all sides are about equal. The sunlight on the snow also shows a tendency to warm all sides of the trees above air temperatures.

The spread between air and bark temperatures is governed chiefly by bark thickness and rate of temperature change. The lag in reaction of bark to air changes depends principally upon bark thickness.

Critical temperatures for broods of the western pine beetle under forest conditions on the Ochoco National Forest, Oregon, were found to be considerably lower than those determined by Miller under laboratory conditions for insects of the same species from North Fork, California. He obtained little or no survival following exposures of −10° F. or lower. In Oregon exposures of −11°, −14°, and −17° F. resulted in survivals of 44.5, 36.0, and 27.6 percent, respectively.

In general it can be said that subzero temperatures usually result in some brood mortality of the western pine beetle and that air temperatures below −15° F. result in important reduction of the broods.

In order to have a more thorough understanding of the relation of air temperature to beetle mortality, further work is necessary to determine the effect of long periods of subzero weather, the importance of the length of exposure at different low intervals, and the lethal temperatures, even of short duration, which are fatal under field conditions to the strains of western pine beetle native to this region.

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IMPROVEMENT IN "APPLE PLUG" TECHNIC FOR TOXICOLOGICAL STUDIES OF THE CODLING MOTH

By E. H. SIEGLER, F. MUNGER, and J. B. GAHAN, *Bureau of Entomology, U. S. Department of Agriculture*

Recently the authors[1] described a laboratory method of testing insecticides against newly hatched codling moth larvae, by using cylindrical plugs instead of entire apples. In this article it was suggested that a codling moth egg in the black-spot stage be placed in each cage, consisting of an apple plug contained in a small glass cylinder. The technic used was described as follows: "(1) The egg on the small piece of wax paper is picked up with a pair of tweezers. With the egg side away from the glass, the paper should be placed in contact with the paraffin coat on the side of the vial just above the apple. With this procedure there can be no question as to the larva's being newly hatched. The importance of using a larva fresh in the strictest sense can hardly be over-emphasized, as the older a larva is the smaller will be its chance of having enough vitality to enter the fruit. (2) Cover the vial with a circular piece of sheeting cloth and fasten it in place with a rubber band."

During the current season an improvement has been made in the method of transferring the egg to the vial and the manner of covering the vial to prevent the escape of the codling moth larva after the egg has hatched. The new method saves considerable time and effort in this part of the work.

The steps in the improved technic are described below and are illustrated in the accompanying plate.

PREPARATION OF STOPPER.—A short tapered cork is first perforated by means of a cork borer or brace and bit (Fig. 139, B). A small piece of sheeting cloth (Fig. 139, C) is pasted over the small end of the cork by means of cement made from 10 grams of celluloid dissolved in 100 cubic centimeters of acetone. (This cement, which is very useful for other laboratory purposes, should be kept well stoppered to prevent evaporation of the solvent.) After the stopper is inserted in the glass cylinder (Fig. 139, A), the edges of the cloth are trimmed by means of a sharp knife (Fig. 139, D).

PIN PICK-UP.—The blunt end of a micro insect pin is pushed through the cloth into the cork by means of a pair of pliers, allowing the pointed end to project a distance of about five-sixteenths of an inch. The cork serves as a holder with which the small piece of waxed paper, bearing

[1] A field and laboratory technique for toxicological studies of the codling moth. E. H. Siegler and F. Munger. Jour. Econ. Ent. 26 (2): 438–445. April 1933.

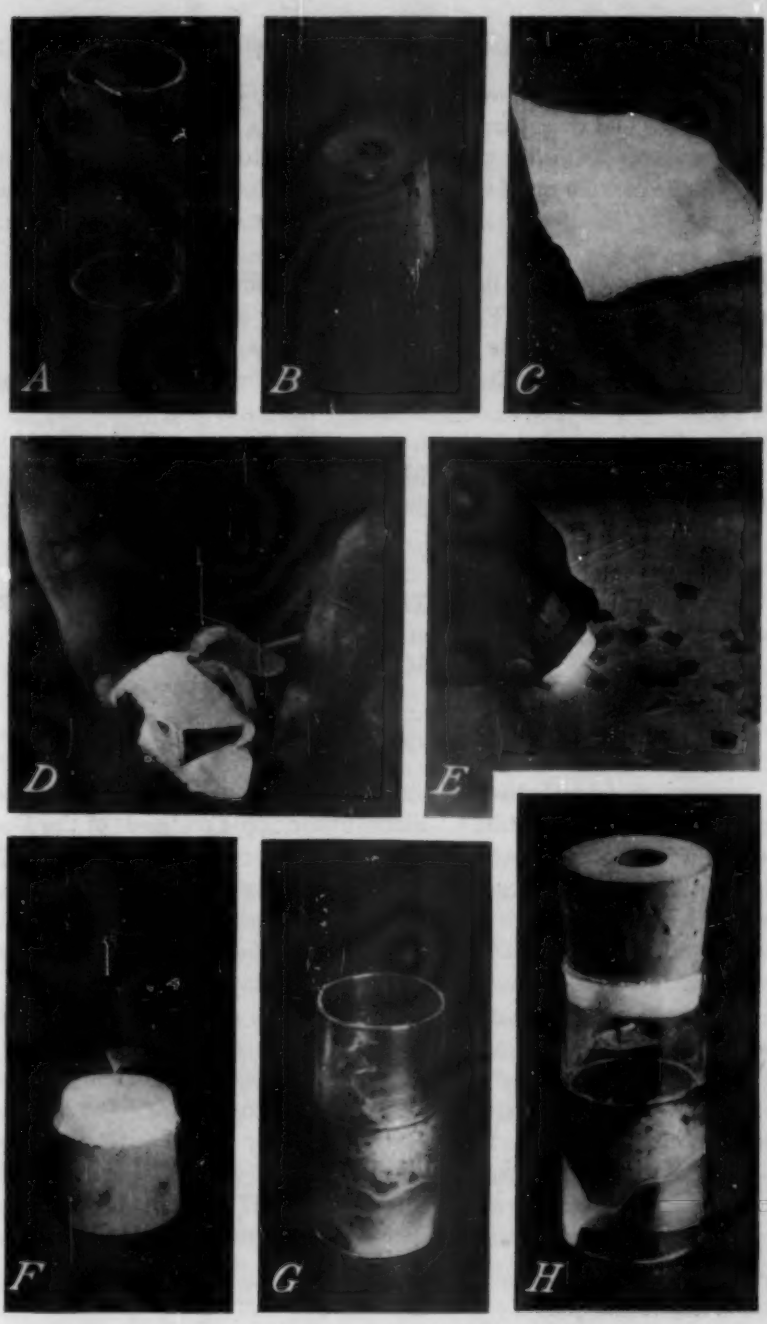

FIG. 139.—A, Glass cylinder; B, perforated cork; C, sheeting cloth; D, trimming edges of cloth cover; E, picking up a piece of waxed paper bearing a codling moth egg; F, waxed paper with egg in place on a pin; G, apple plug sealed in a glass cylinder; H, completed assembly.

an egg, is picked up as shown in Figure 139, E. The cork stopper and pin are used over and over throughout the season.

CLOTH PAD.—In order to prevent damage to the pin point and to facilitate the picking up of the waxed paper, a cloth pad is used as shown in Figure 139, E. The picking up of the eggs is thus readily accomplished.

Egg in place: The paper holding the egg remains attached to the pin as illustrated in Figure 139, F.

Enclosed plug: The apple plug sealed in the glass cylinder is shown in Figure 139, G; and, with cork stopper and egg in place, in Figure 139, H.

When the egg has hatched the emerged larva either lowers itself by means of a silk thread to the apple plug or else crawls up to the pin to the cloth and thence down the vial to the fruit.

A PROGRESS REPORT ON THE CONTROL OF THE CHERRY CASE BEARER (*COLEOPHORA PRUNIELLA*, CLEM.) IN WISCONSIN

By J. H. LILLY and C. L. FLUKE, *Department of Economic Entomology, University of Wisconsin*[1]

The development of effective control measures against the cherry case bearer, *Coleophora pruniella*, Clemens, in the apple orchards of the Door Peninsula fruit-growing area of Wisconsin was reported last year.[2] The work in 1932 centered largely around the use of petroleum oil emulsions, which gave good control but often resulted in excessive tree injuries. Consequently the 1933 experimental plots consisted principally of trees sprayed with dormant lime sulfur and a tar oil wash.

The procedure of preparing and applying the various spray materials and the method of determining the percentage of kill of the case bearer were the same as reported for 1932. The work was also continued in the same orchards and with the same spraying equipment. The smallest plots included 10 trees each but the majority contained 52 or more trees. Almost all of the experimental trees were of the Wealthy variety. Table 1 summarizes the results obtained from 17 of the 30 experimental plots. The figures indicating the concentration of the lime sulfur sprays

[1]This paper is published with the consent of the Director of the Wisconsin Agricultural Experiment Station ————————.

[2]Lilly, J. H., and Fluke, C. L. 1933. New developments in the control of the Cherry Case Bearer (*Coleophora pruniella* Clem.) in Wisconsin. Jour. Ec. Ent. *26:* 805–812.

denote the number of gallons of spray material to which one gallon of Dow lime sulfur solution (33° or 34° Bé) was diluted. Thus 1–10 means that 10 gallons of lime sulfur solution were added to 90 gallons of water to make up 100 gallons of spray solution.

A total of 15 plots of dormant lime sulfur were used. The concentrations used ranged from 1–6 to 1–12; some had supplementary materials (arsenate of lead or blood albumen) added with the hope of increasing their efficiency; and the dates and temperatures at the time of making the different applications varied widely. The resulting kills ranged from 76.5% to 98.8%. Plots 4 to 7 inclusive at concentrations of 1–12, 1–10, 1–8, and 1–6 gave kills of 84.1%, 89.5%, 90.7%, and 94.8% respectively. Hence the concentration of the dormant lime sulfur sprays was directly related to the degree of control secured.

Plots 8, 9, and 10 of 1–10 lime sulfur, 1–10 lime sulfur plus 2–50 arsenate of lead, and 1–10 lime sulfur plus ½–100 blood albumen, gave kills of 88.5%, 82.9%, and 85.2% respectively. Thus in this comparison 1–10 lime sulfur alone gave a slightly higher kill than did the same concentration when supplemented with either arsenate of lead or blood albumen. However, plot 11 of 1–10 lime sulfur and plot 12 of 1–10 lime sulfur plus 2–50 arsenate of lead, located in another orchard, were sprayed on April 15 and gave kills of 85.0% and 90.7% respectively. Also plot 13 of 1–10 lime sulfur and plot 14 of 1–10 lime sulfur plus ½–100 blood albumen in the latter orchard were sprayed on April 26 and gave kills of 76.5% and 79.6% respectively. The conflicting and relatively slight differences in degree of control obtained from these comparisons indicate that neither arsenate of lead nor blood albumen (a wetting agent) materially altered the dormant lime sulfur sprays as controls for the case bearer.

The next comparison of plots tends to show a probable relation of the time of application to the effectiveness of lime sulfur in killing the case bearer. Plots 1, 11, and 13 of 1–10 lime sulfur were sprayed on November 14, 1932, April 15, 1933, and April 26, 1933; and gave kills of 95.8%, 85.0%, and 76.5% respectively. Plots 2 and 6 of 1–8 lime sulfur were sprayed on November 14, 1932 and April 20, 1933; and gave 98.3% and 90.7% kill respectively. Plots 3 and 7 of 1–6 lime sulfur sprayed on November 14, 1932 and April 20, 1933, gave kills of 98.8% and 94.8% respectively. None of the fall-sprayed plots were entirely comparable to those sprayed in the spring. Plot 1 was a row of McMahans, and 2 and 3 were of the Duchess variety, while the spring spraying included Wealthy, Snow, and Northwestern Greening trees. The fall spraying was very thoroughly done on a cool day and it was followed immediately by a

TABLE 1. RESULTS WITH CASE BEARER SPRAYS ON APPLES—1933

Plot	Materials	Rate	Date	Temp. F.°	Results			Remarks
					Total	Surviving	Per cent kill	
—	Unsprayed	——	————	—	55,160	30,426	0	44.8% normally "dead" in Bingham orchard
—	Unsprayed	——	————	—	7,665	4,418	0	42.4% normally "dead" in Nebel orchard
1	Lime sulfur and lead arsenate	1–10 2–50	11/14/32	34	6,709	157	95.8	Plots 1 to 3 inclusive sprayed November 14, 1932. All were very thoroughly sprayed.
2	Lime sulfur	1–8	11/14/32	34	6,863	64	98.3	
3	Lime sulfur	1–6	11/14/32	33	6,773	45	98.8	
4	Lime sulfur	1–12	4/20/33	62	15,679	1,380	84.1	Good commercial spraying
5	Lime sulfur	1–10	4/20/33	61	16,334	945	89.5	Good commercial spraying
6	Lime sulfur	1–8	4/20/33	59	14,535	744	90.7	Good commercial spraying
7	Lime sulfur	1–6	4/20/33	55	16,008	459	94.8	Good commercial spraying
8	Lime sulfur	1–10	4/24/33	66	17,907	1,136	88.5	Good commercial spraying
9	Lime sulfur and lead arsenate	1–10 2–50	4/24/33	70	15,703	1,478	82.9	Good commercial spraying
10	Lime sulfur and blood albumen	1–10 ½–100	4/24/33	71	15,939	1,299	85.2	Good commercial spraying
11	Lime sulfur	1–10	4/15/33	44	7,870	678	85.0	Good commercial spraying
12	Lime sulfur and lead arsenate	1–10 2–50	4/15/33	49	7,025	378	90.7	Good commercial spraying
13	Lime sulfur	1–10	4/26/33	37	6,903	936	76.5	Good commercial spraying
14	Lime sulfur and blood albumen	1–10 ½–100	4/26/33	39	7,597	894	79.6	Good commercial spraying
15	"Barko".....	8%	4/20/33	56	15,582	294	96.6	Good commercial spraying
16	"Barko"	6%	4/20/33	59	14,851	715	91.3	Good commercial spraying
17	"Barko"	4%	4/20/33	62	15,330	1,303	84.6	Good commercial spraying

light rain. The spring dormants were applied with the thoroughness of a good commercial grower, and the work was done under comparatively favorable weather conditions. Also Plot 1 contained 2–50 arsenate of lead and Plots 11 and 13 were in a different orchard from the others and were sprayed with another machine. However, the tendency of all the lime sulfur plots sprayed in the late spring dormant stage to give a comparatively low kill substantiates the above evidence that the time of application is of major importance directly in controlling the effectiveness of dormant lime sulfur as a case bearer control, and that the earlier such sprays are applied the more efficient they will probably prove to be.

The temperature at the time of making spray applications has so far failed to show any positive correlation with the killing efficiency of lime sulfur or any of the other sprays tried against the case bearer.

"Barko" was the tar oil wash tried and results with it were most encouraging. At 8%, 6%, and 4% concentrations it gave kills of 96.6%, 91.3%, and 84.6% respectively. A great advantage of the tar oil washes is that they may be successfully used against both aphis eggs and bud moth (*Tmetocera ocellana*) larvae on apple trees. "Barko" at 8% also appeared to materially check injuries by the fruit-tree leaf-roller (*Archips argyrospila*), but the lower concentrations were probably of little value in this respect.

The "cold-mix" oils tried were "Spuria" and "Tiara." "Spuria" at 8%, 7%, and 6% gave 97.7%, 97.7% and 95.0% kills respectively. "Tiara" at the same concentrations gave kills of 89.6%, 90.6%, and 92.0% respectively. The slightly lower kills resulting from the 8% and 7% applications of "Tiara," as compared to the 6% plot, were apparently due to the poor coverage which resulted from the high winds that prevailed when these plots were sprayed. Thus, in a sense, the time of application also has an indirect influence upon the effectiveness of any spray used against the case bearer, as strong winds are decidedly detrimental to thorough spraying. A miscible oil, "Cen-pe-co" at 8% gave a kill of 91.4%. Another miscible oil, "Dendrol," gave kills of 87.3% and 76.0% at 8% and 6% concentrations respectively, but the latter two plots were sprayed with an inferior machine and the relatively low kills obtained were probably due mainly to this cause.

Several additional materials were tried in an attempt to develop other satisfactory spray recommendations. These included" Dowspray," "Ansul" colloidal sulfur, and carbolic lime in the dormant stage; and arsenate of lead 3–50 plus summer strength lime sulfur in the pre-pink stage. None of these combinations gave anything approaching a satisfactory control.

The total case bearer population of a single apple tree was found by an actual count made in the dormant stage to be approximately 175,000. This figure serves to emphasize two important points. First, it gives an indication of the tremendous insect handicap which an infested tree must cope with if it is left unsprayed, and it also shows the potential population of egg-laying adults which an unsprayed orchard may produce. Second, when such great numbers are present, the hibernating cases are often so closely packed on the undersides of the spur crotches that only thorough spraying from the lower sides of the limbs can result in satisfactory control, regardless of the material applied.

Oil Injuries.—Both observations and counts were made this year in order to evaluate and compare the detrimental effects of the various spray materials used upon the host trees. No deleterious effects of any kind were found after dormant applications of lime sulfur. The tar oil wash "Barko" killed a few buds, especially at the 8% strength, but it compared favorably with lime sulfur so far as lack of serious tree injuries was concerned. Neither of the plots sprayed with 8% miscible oil ("Cen-pe-co" and "Dendrol") showed any serious destruction of buds. However, all the plots treated with "cold-mix" oil emulsions, including both "Spuria" and "Tiara" at 6%, 7%, and 8% strengths, showed a considerable number of "burned" or dead buds present. This injury was probably accentuated this year by the weakened and perhaps partially dessicated condition of the apple trees of this region, due to shallow soil and a lack of rainfall over the past four growing seasons

Summary and Conclusions

1. Some dormant lime sulfur plots gave satisfactory control of the case bearer, especially the fall applications. There is also some evidence that early spring dormant applications of this material are more effective than those applied later in the spring dormant stage.

2. Dormant lime sulfur should be used at a concentration of 1–8 for case bearer control.

3. Neither arsenate of lead nor blood albumen appeared to materially increase the effectiveness of dormant lime sulfur as a case bearer control.

4. A "cold-mix" petroleum oil of low viscosity ("Spuria") appeared to be superior to a "cold-mix" oil of medium viscosity ("Tiara") for case bearer control, and it is probably less dangerous to the host trees.

5. "Cold-mix" oil emulsions need not be used in concentrations higher than 6% for case bearer control, and even this strength is highly detrimental to both fruit and leaf buds under some conditions.

6. Miscible oils were not quite as toxic to the case bearer as the "cold-mix" preparations, although they are probably less apt to cause tree injuries.

7. A tar oil wash ("Barko") gave effective case bearer control at 8% and 6% concentrations.

8. Each of these three types of dormant spray materials has both advantages and disadvantages as a case bearer control under average orchard conditions. Dormant lime sulfur seems to be entirely harmless to fruit trees, but it fails to check two other serious apple pests, bud moth and fruit-tree leaf-roller. The petroleum oil emulsions result in more or less tree injury, but they usually give satisfactory control of the leaf-roller. The tar oil wash used ("Barko") apparently does not seriously injure the host trees, and the higher concentrations of it seem to give partial control of both bud moth and fruit-tree leaf-roller.

9. Thorough spraying from the ground is again emphasized as the keynote to successful case bearer control.

ACKNOWLEDGMENTS.—The writers wish to express their sincere appreciation to D. E. Bingham, M. H. Bingham, N. C. Jacobs, and L. P. Nebel, Sturgeon Bay, Wisconsin, fruit growers for their cooperation in conducting field work in 1933; to the Dow Chemical Company for the lime sulfur solution used; and to the William Cooper and Nephews Co. for the "Barko."

FIELD EXPERIMENTS WITH *BEAUVERIA BASSIANA* (BALS.) VUILL., A FUNGUS ATTACKING THE EUROPEAN CORN BORER

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During the course of an investigation of insect parasites of the European corn borer (*Pyrausta nubilalis* Hbn.), one lot of corn-borer larvae imported from Manchuria was found to be infected with the entomogenous fungus *Beauveria bassiana* (Bals.) Vuill., and when subjected to conditions favorable for hastening the emergence of insect parasites from 80 to 90 per cent of these larvae were killed. Because of this ex-

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[2]The authors wish to express their thanks to D. W. Jones, in charge of the European corn borer laboratory at Arlington, Mass., for helpful suggestions throughout the course of this investigation. They also wish to thank Prof. W. H. Weston, Jr., for his helpful criticism in the preparation of this manuscript and for laboratory facilities made available at Harvard University. Thanks are also extended to Dr. D. H. Linder, of Harvard University, for kindly reviewing the manuscript.

ceedingly high mortality it was thought worth while to conduct tests to determine if this fungus can be used to aid in controlling the European corn borer in the United States.

PREVIOUS INVESTIGATIONS OF ENTOMOGENOUS FUNGI IN INSECT CONTROL.—Entomogenous fungi as a factor in the control of destructive insects have been the subject of much discussion, but they have not proved sufficiently effective to justify their propagation and artificial distribution. Petch (*3*) summarizes the work done on entomogenous fungi and concludes that results do not warrant their use for the control of insect pests. Rorer (*4*) reports that from 80 to 90 per cent of the frog leafhoppers on sugarcane in Trinidad were killed when *Metarrhizium anisopliae* (Metsch.) Sorokin was artificially spread on the fields. According to Morrill and Back (*2*), the work done in Florida on the control of white flies with various species of *Aschersonia* did not bring encouraging results from the standpoint of practical control. These experimenters with entomogenous fungi, however, have attempted to increase the natural control of destructive insects by artificial propagation and dissemination of a parasitic fungus already present in the area, whereas *Beauveria bassiana* has never been known to occur naturally in the United States on the European corn borer. Furthermore, the insects concerned were primarily external feeders, thus being exposed to climatic conditions often unfavorable to the development of the fungus. The European corn borer, however, is primarily an internal feeder ensconced within the succulent tissues of the cornstalk, which afford an ideal environment for fungus development.

DESCRIPTION AND PARASITIC HABITS OF *Beauveria bassiana*.—The genus *Beauveria* is included in the tribe Verticillieae of the *Fungi Imperfecti*. Before reclassification by Vuillemin (*6*) in 1912, the species was known as *Botrytis bassiana* Bals.

Observations on spore germination and development have been previously reported as follows (*1*): "Studies of spore germination were made by placing conidia in drops of distilled water ***. In 24 to 48 hours the spores swelled and put out one or more slender thin-wall germ tubes containing clear hyaline protoplasm. *** After 32 hours the germ tubes *** range *** from a few microns to about 80μ and the branches arising from these were very short. At this stage of development conidial production is evident. *** Later, when *** producing conidia abundantly, they are borne in rather compact, globose heads, either on the main hyphal branches or on short laterals that are usually at right angles to the main axis. *** Frequently this branching is repeated, forming compact heads whose make-up is difficult to follow."

The germ tube penetrates the larval skin of the corn borer through the thin sclerotic folds between segments, and hyphae begin to develop within the body cavity.

The presence of the disease is first manifested on the corn-borer larvae by their becoming rather sluggish and failing to respond readily to external stimuli. After death the larvae usually turn a characteristic pink color and begin to harden, becoming mummified about 1 day after the pink color appears. When the mummified larvae are kept in a humid atmosphere, a white mycelial growth covers the entire body within a few days, and abundant spore formation soon takes place, which gives the larva a cream-colored, floury appearance and affords abundant inoculum for further infection. There seems to be very little doubt that the disease is spread from one corn-borer larva to another, for when a diseased larva is found in the tassel many larvae below this point are also found to be diseased. (As many as 17 larvae killed by the fungus have been found in one stalk.)

PRELIMINARY EXPERIMENTS.—Under laboratory and field conditions it was possible to infect all larval stages of the European corn borer; the tender tissues of the young larvae were most susceptible to fungus invasion, however, and the smaller instars were the first to be killed after inoculation. Two infected pupae found in cornstalks failed to produce adults after being brought into the laboratory. When spores of *Beauveria bassiana* were dusted over pupae placed in a humid atmosphere, the fungous development prevented the emergence of the adults. It was also possible to infect corn-borer eggs, when they were placed in a moist chamber, by dusting spores of the fungus over the egg masses. Since most of the egg masses found under natural conditions in the field are laid on the undersides of the lower leaves, there is very little chance of their becoming infected. As a control measure this fact is relatively unimportant, but it is of interest from a mycological viewpoint.

The results of laboratory tests (*1*) showed that the fungus *Beauveria bassiana* was extremely virulent and readily killed the European corn borer larvae after they had been inoculated with the spores. Corn was found to be a favorable host plant, as the tassels and the axils of the leaves offer suitable locations for the accumulation of spore material and at the same time are the most often penetrated by the corn-borer larvae.

PREPARATION OF MATERIAL FOR INOCULATION IN THE FIELD.—The fungus spores first used for field experiments were grown in various types of Petri dishes and later large galvanized trays were used with fairly good success; but since this did not afford sufficient spore ma-

terial, a culture cabinet was obtained from the gipsy moth laboratory.[3] This cabinet contained 11 trays 3 feet long by 2 feet wide and was similar in design to that described by Rorer (5). Corn-meal mush was found to be a suitable medium for growing the fungus in trays. This mush was steamed 1 hour on 2 successive days and then the surface was dusted by means of an atomizer with a mixture of spores in sterilized flour. After 3 or 4 days' incubation at room temperature the entire surface of the mush became covered with a white mycelial growth. The trays were then taken out and placed in an open room, thus affording rapid drying of the substratum, which greatly hastened spore formation and made a firm surface from which spores could easily be brushed.

During the field experiments of the first season cornstarch was used as a carrier. Later laboratory experiments showed that common wheat flour supported better growth of the fungus and was equally effective as a carrier; consequently in the later field experiments this material was used. It was often observed that after a dew or light rain the fungus was growing and sporulating on the moist flour which had accumulated in the axil of the corn leaf, thus confirming the results found in the laboratory.

The principal disadvantage in carrying out the field experiments has been the limited quantity of spore material obtainable when the fungus is grown on Petri dishes; but by the use of the culture cabinet mentioned above a larger quantity can be obtained.

EXPERIMENTS CONDUCTED IN 1930.—In the summer of 1930 field experiments were started on a privately owned farm at West Medford, Mass. Two adjacent pairs of fields of approximately 1 acre each were selected. One field of each pair was dusted with spores of *Beauveria bassiana* and the other was used as a check. The cornborer eggs laid on the plants in 10 widely separated hills were counted twice weekly in each of the four fields throughout the egg-laying period. The fields were dusted with a hand duster 1 week after the peak of egg-laying had been reached, and again after all the eggs in the field had hatched. The spore material was directed at the top of the plant, which at the time of the last application was just tasseling. The foregoing test was carried out on the first-generation larvae. Later a similar test on second-generation larvae was conducted on a privately owned farm at Saugus, Mass. This test differed from the first only in the quantity of spores applied per acre. The results of the first year's experiments are summarized in Table 1.

[3]The authors wish to thank C. W. Collins and M. T. Smulyan for the use of this cabinet.

TABLE 1. RESULTS OF DUSTING CORN PLANTS INFESTED WITH FIRST- AND SECOND-GENERATION CORN-BORER LARVAE WITH SPORES OF *Beauveria bassiana* UNDER FIELD CONDITIONS IN 1930

Plot[1]	Spores applied per acre	Hills examined	Eggs hatched	Observations recorded from dissections of infested corn plants				
				Living larvae and pupae	Larvae dead from *B. bassiana*		Larval survival	Reduction in living larvae in dusted plots
	Grams	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*
First-Generation Larvae at West Medford, Mass.								
A....	13	10	175	20	8	28.6	11	15
B....	0	10	72	19	0	——	26	——
C....	0	10	96	50	0	——	52	——
D....	3	10	293	55	4	6.8	19	33
Second-Generation Larvae at Saugus, Mass.								
A....	20	20	801	181	81	30.9	22.6	31.2
B....	0	20	1,032	555	3[2]	——	53.8	——
C....	0	10	277	204	0	——	73.6	——
D....	10	10	678	219	3	1.4	32.3	41.3

[1]Plots B and C were check plots, Plot B being a check on Plot A and Plot C being a check on Plot D.
[2]In one stalk.

It is apparent from Table 1 that when spores of *Beauveria bassiana* were dusted over corn plants the fungus killed the larvae of the European corn borer in numbers varying with the number of grams of spores used per acre. For the first-generation test the quantities of spores applied per acre in Plots A and D were 13 and 3 grams, respectively. Dissections of 10 hills of corn in Plot A revealed that 28.6 per cent of the larvae were dead from *Beauveria bassiana;* in Plot D, 6.8 per cent were dead. By dividing the number of living larvae by the number of eggs hatched, the larval survival was found to be 11 per cent in Plot A and 19 per cent in Plot D, whereas in the check plots the larval survival was 26 and 52 per cent, respectively. The application of a greater quantity of spores per acre resulted in a decrease in the number of corn-borer larvae which survived and became established. The reduction in larval survival in dusted Plot A over that in its respective check plot B was found to be 15 per cent. In Plots C and D the difference in percentage was found to be 33.

These experiments show that there was a reduction in the number of living larvae in the dusted plots but that the percentage of recovered larvae dead from fungus disease does not account for the high percentage of larvae that failed to become established. Two factors, however, must be taken into account. It was observed, first, that some of the diseased larvae sought the outside of the plant and after death were easily blown

to the ground; second, that it is almost impossible to recover the first- and second-instar larvae owing to their small size and the fact that they were seldom found when the plant was dissected. Laboratory tests have shown, however, that the young larvae are very susceptible to the attacks of *Beauveria bassiana* and undoubtedly these small larvae were not recovered although they actually succumbed to the disease.

In the second generation it was again found that by using a greater quantity of spore material per acre the percentage of larvae dead from *Beauveria bassiana* was greatly increased. In this case 30.9 per cent of the larvae were found dead from the disease when 20 grams of spores per acre were used as compared with 1.4 per cent when 10 grams of spores were used, the reduction in larval survival for the dusted Plot A over check plot B was 31.2 per cent, and for the dusted Plot D over check plot C, 41.3 per cent.

EXPERIMENTS CONDUCTED IN 1931.—During the summer of 1931 field tests were continued on both the first and second generations of the European corn borer in an attempt to learn more of the parasitic nature of *Beauveria bassiana*. The first-generation test was conducted at West Medford, Mass., in a field of about one-half acre planted to sweet corn. The corn was a low-growing variety and had been planted very early. The field was divided into two plots of equal size separated by barrier rows, one plot to be dusted with spore material and the other to be used as a check. Two applications of spore material were made at the rate of 20 grams per acre. The first application was made at the first signs of larval feeding and the second application when practically all the eggs had hatched. In this experiment flour was used as a carrier at the rate of 8 pounds to 10 grams of spores. The results are given in Table 2.

From Table 2 it is again evident that by increasing the number of spores applied per acre the number of larvae killed by the disease was markedly increased. When the corn plants in 70 hills spread throughout the dusted plot were dissected, it was found that an average of 71.3 per cent of the larvae and pupae had been killed by *Beauveria bassiana*. In the corn plants in the first barrier row 7.8 per cent of the larvae were found dead from the disease, showing that the spore mixture was scattered to some extent during the process of dusting. The reduction of living larvae in the dusted plot over the check was found to be 70.4 per cent. Although there are no definite figures as to the actual reduction of damage done by the feeding larvae, the grower was of the opinion that the dusted plot yielded a greater number of marketable ears than did the check.

TABLE 2. A SUMMARY OF THE RESULTS OF FIELD EXPERIMENTS IN WHICH CORN PLANTS INFESTED WITH FIRST-GENERATION LARVAE OF THE EUROPEAN CORN BORER WERE DUSTED WITH SPORES OF *Beauveria bassiana* AT THE RATE OF 40 GRAMS (TWO APPLICATIONS OF 20 GRAMS EACH) PER ACRE AT WEST MEDFORD, MASS., 1931

Plot	Row No.[1]	Stalks per 10 hills	Observations recorded from dissection of infested corn plants: Living larvae and pupae	Larvae and pupae killed by *B. bassiana*	
		Number	*Number*	*Number*	*Per cent*
Dusted	1	44	12	20	62.5
	2	45	8	20	71.4
	3	45	15	38	71.7
	4	44	21	43	67.2
	5	57	13	49	79.0
	6	51	21	54	72.0
	7	63	20	62	75.6
	Average		15.7	—	71.3
Barrier	10	48	83	7	7.8
Check	2	44	35	0	——
	4	46	55	0	——
	7	48	69	0	——
	Average		53	—	——
	Reduction in living larvae in dusted plot		70.4 per cent		

[1]Ten hills were examined in each row.

A second-generation test was conducted in a 1-acre plot of a variety of sweet corn which grew exceedingly tall, so that it was difficult to apply the spore material with a hand duster. Six separate plots of 50 hills each were selected for further tests to determine the effect of varying the number of applications of spore material of different concentrations. Plots A and B were dusted five times at weekly intervals beginning July 17, when eggs were first noted to be hatching. Plot A was dusted at the rate of 95.5 grams per acre, and Plot B at the rate of 382 grams per acre. Plots E and D were dusted once with the same quantities, respectively, of spore material as were used in Plots A and B. These applications were made when approximately 75 per cent of the eggs had hatched. Plot F was dusted four times at weekly intervals at the rate of 38.2 grams per acre, the first application being on July 24. Two rows running the entire length of the field were used as checks and these were designated as Plot C. Egg counts were made twice a week during the period of oviposition. In these experiments flour was again used as a carrier at the rate of 1 pound for each application to each plot of 50 hills. These results are summarized in Table 3.

In Table 3 it is clearly shown that there was a remarkable reduction of living larvae in the dusted plots and that the number of larvae killed was greatly increased by increasing the number of applications of spore material. There was a reduction in living larvae of approximately 28

TABLE 3. A SUMMARY OF THE RESULTS OF FIELD EXPERIMENTS IN WHICH CORN PLANTS INFESTED WITH SECOND-GENERATION LARVAE OF THE EUROPEAN CORN BORER WERE DUSTED WITH SPORES OF *Beauveria bassiana* AT WALTHAM, MASS., 1931[1]

Plot	Spores applied per acre	Applications	Observations recorded from dissections of corn plants: Stalks per 10 hills	Eggs hatched	Living larvae	Larvae dead from *B. bassiana*		Larval survival	Reduction in living larvae in dusted plots
	Grams	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*
A.....	95.5	5	34	1,130	24	20	45.5	2.12	27.92
B.....	382	5	37	810	21	63	75.0	2.59	27.45
C (check)..	——	–	32	709	213	10	4.5	30.04	——
D.....	382	1	34	667	126	3	2.3	18.89	11.15
E.....	95.5	1	31	592	126	10	7.3	21.28	8.76
F.....	38.2	4	34	757	52	54	50.9	6.87	23.17

[1]Ten hills were examined in each plot of 50 hills.

per cent in both Plots A and B, which received five applications of spore material, while in Plots D and E, where the same quantities of spore material were used but in one dusting, the percentage reduction in living larvae was much lower. Plot F received four applications at the rate of 38.2 grams per acre, the total quantity applied (152.8 grams) being less than one half the total quantity applied in Plot D; yet the reduction in living larvae was over twice as great, showing that a series of applications is more effective than a single application.

It is again evident that the percentages of larvae dead from *Beauveria bassiana* are relatively high, but this does not account for the high percentage of reduction in living larvae in the dusted plots. Since this reduction has been duplicated each time in previous field experiments, it seems certain that a large number of the early stages of the larvae were killed by the fungus which were not discovered on dissection of the plant.

Ten larvae dead from disease (see Table 3) were found in the check plot, again showing the dispersal of the spores by the wind at time of dusting or the migration of diseased larvae from the dusted plots to the check.

During the season of 1931 attempts were made to establish the fungus in weed areas, where many of the corn-borer infestations originate. This was done on the theory that the natural disintegration of infested weeds would expose dead corn-borer larvae covered with a powdery layer of spores. These spores would be scattered by wind and other agencies, thus affording the opportunity for other corn-borer larvae to become infected the following season. In these experiments a number of locations for the dispersal of the fungus were chosen in order to give as large a variation in environmental conditions as is possible to insure establishment. Weed areas in dumps at East Boston and Everett, Mass., were selected, and spore material was applied to these areas three times during the season. Both areas have shown a fairly large percentage of borers killed by this fungus. One entire township (Middleboro, Mass.) was also chosen as an area for distribution of the fungus, and a single application of spore material was made at the time when the number of young second-generation larvae was at its peak. Several cornfields and suitable weed areas in the town were dusted with spores of *Beauveria bassiana*.

In August 1932 the first definite proof of the establishment of the fungus was found at East Boston, Mass., when first-generation larvae present in cocklebur plants were discovered to have been killed by *Beauveria bassiana*. As no liberations of spores had been made in or near this

locality since the summer of 1931, it was assumed that the fungus successfully overwintered and reinfected new larvae the following season. However, subsequent dissections in weeds at East Boston and Everett, Mass., at the time when second-generation larvae were present in the field failed to result in recovery. Thus far the fungus has not been recovered in Middleboro, Mass.

During the season of 1932 a large number of liberations of spore material were made in the single-generation area of the corn borer (in New York, Pennsylvania, Ohio, and Michigan), but the results of these liberations are not known.

DISCUSSION OF RESULTS.—It is impossible at the time of dissection of the corn plant, or at the time when a check is necessarily made on these experiments, to know whether or not living larvae recovered will be infected by the fungus after larval counts have been made. Without doubt there is some increase in the number killed by the disease because many such larvae show the early symptoms of the disease, as previously mentioned for laboratory experiments.

Although the number of spores used per acre is significant in relation to the number of larvae killed by the disease, several other factors must be considered. As in the application of an insecticide against any insect, the efficiency of the spore treatment depends on the proper coverage of the plant. In this case a spore of the fungus must come in contact with the larva; therefore, the size of the corn plant is an important factor in determining the quantity of spore material necessary to insure proper coverage. Atmospheric conditions at the time of and shortly after dusting also have an important bearing on the final results.

The experiments thus far have shown that European corn borer larvae in the field are readily susceptible to attack by *Beauveria bassiana*. It is possible, by dusting fields of infested corn and weeds with a mixture of spores and flour, to infect larvae and obtain a high reduction in the larval survival. The application of spores from year to year is probably impractical on a large scale even though it might prove very helpful in the control of the borer. In small plots and in places where herbaceous ornamentals are grown, the use of this fungus as an aid in controlling the corn borer might prove feasible if proper methods of propagation and distribution could be worked out.

The results show that the fungus can successfully overwinter and reestablish itself on new larvae the following year, but as yet the recovery data are insufficient to indicate whether or not the fungus will prove to be of value as a natural enemy under field conditions. All recoveries thus far have been made in weed areas where natural disintegration

of the plant affords exposure of dead larvae and a good opportunity for reinfection. The establishment of the fungus in corn-growing areas remains in doubt. In this connection an interesting infestation has appeared in the experimental plots formerly used by the Sandusky, Ohio, laboratory. During the season of 1932 between 1 and 2 per cent of the larvae in these plots were killed by *Beauveria bassiana*. A small number of larvae killed by the fungus had been noted for 2 to 3 years previously. It is possible that the disease has become established naturally in this area and that it is gradually showing an increase. It is known, however, that the fungus was present in the laboratory and the rearing of larvae under artificial conditions has been impaired by the mortality caused by this fungus. It is possible that spores may have been transmitted on equipment or clothing and that this infection was due to artificial propagation and accidental dispersion of spores; therefore, it cannot be definitely stated that the fungus was established naturally. Observations in this area over a period of years may possibly clear up this point and give definite evidence as to the value of the disease.

It is unwise to estimate the time that may be required for this fungus to establish itself and become a factor in the control of the corn borer. There is no guide or precedent for determining when an adequate quantity of spores has been liberated to bring about natural control or even to obtain initial establishment of the fungus. Furthermore, the particular needs of such a fungus as to environmental, atmospheric, and proper growing conditions are uncertain. It is with these qualifications in mind that the work has been carried on and the attempt made to establish the fungus under various conditions in a number of environments. It is felt that work along this line should now be held in abeyance until there is evidence of natural establishment and the fungus has shown its ability to perform its part in the natural control of the European corn borer.

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A COMPARISON OF THE LIFE CYCLES OF *FRANKLINIELLA TRITICI* (FITCH), *F. FUSCA* (HINDS) AND *THRIPS TABACI* LIND. (THYSANOPTERA-THRIPIDAE) IN SOUTH CAROLINA

By J. G. WATTS[1]

The increasing importance of Thysanoptera (Thrips) in relation to the cotton seedlings in South Carolina has brought about the necessity of making life history studies of three species. The three species of major importance are *Frankliniella tritici* (Fitch), the flower thrips; *F. fusca* (Hinds), the tobacco or cotton thrips; and *Thrips tabaci* Lind., the onion thrips. In advancing control measures for any of them one or more species will be involved in a number of cases, and consequently a knowledge of the life cycle of the three species is quite important. Life history studies of each of these species were made at the same time and under identical conditions during the five months from May to October, 1932. Extensive biological studies are being made of *F. tritici*, the results of which will be published at a later date.

In the following table (Table 1) is a comparative presentation of the duration of the various instars in the development of the three species mentioned above.

TABLE 1. A COMPARISON IN DAYS OF THE DURATION OF THE DIFFERENT INSTARS IN THE LIFE CYCLE OF *F. fusca*, *F. tritici*, AND *T. tabaci* RUN UNDER IDENTICAL CONDITIONS AT THE SAME TIME

Species	Number Completed cases	Incubation			1st Larval		
		Ave.	Max.	Min.	Ave.	Max.	Min.
F. fusca	493	6.71	10	3	2.28	5	1
F. tritici	470	3.32	8	2	2.04	5	1
T. tabaci	401	4.56	9	2	2.03	4	1

Species	2nd Larval			Prepupa			Pupa		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
F. fusca	3.54	8	1.0	1.11	3	1.0	2.63	6	1
F. tritici	2.36	7	.5	1.07	4	.5	2.35	6	1
T. tabaci	2.80	6	1.0	1.13	4	1.0	2.73	5	1

Species	Developmental			Preoviposition			Total Life Cycle (From egg to egg)
	Ave.	Max.	Min.	Ave.	Max.	Min.	
F. fusca	15.91	23	8	2.59	5	2	18.50
F. tritici	11.03	21	8	3.98	7	1	15.01
T. tabaci	13.21	19	10	3.09	5	1	16.30

The most significant point brought out in these data is the difference in the incubation period. It is shown that the incubation period for *F. fusca* is more than twice that of *F. tritici*, and significantly more than that of *T. tabaci*. This point has considerable bearing when the appli-

[1]Technical contribution No. 37 from the S. C. Experiment Sta., Clemson College, S. C.

cation of an insecticidal control is involved in an association of the three species. It will be seen therefore, that in order for a given application of an insecticide to be most effective against all three species it would of necessity be applied at a time when the two latter species are in the second larval stage and the former species in the first stage.

A summary of some of the more significant figures regarding the three species under consideration is shown in Table 2.

TABLE 2. A COMPARISON OF THE LONGEVITY, PROLIFICACY, AND TOTAL LIFE CYCLE OF *F. fusca*, *F. tritici*, AND *T. tabaci* RUN AT THE SAME TIME AND UNDER IDENTICAL CONDITIONS

	F. fusca	F. tritici	T. tabaci
Longevity in days of the adult female	29.08	21.42	18.33
Average number of eggs per female*	55.50	41.25	44.25
Total life cycle in days	18.50	15.01	16.30

*No satisfactory means has been devised for determining the number of thrips eggs in a leaf tissue without disturbing normal incubation; therefore, the number of eggs laid has been based on the number of larvae actually emerging from the leaf.

A comparison of the life histories of the three species shows that *F. fusca* has the longest life cycle, lays the largest number of eggs per female, and lives the longest in the adult stage. *F. tritici* has the shortest life cycle, lays the least number of eggs per female, but in the adult stage lives slightly longer than *T. tabaci*.

Each of these species may be found in the field during every month in the year in South Carolina, but their noticeable destructiveness usually begins sometime about the latter part of March or in April in the Piedmont section of the state and continues to a greater or less degree until about September or October. In the eastern part of the state spring activity begins earlier and continues later in the fall. The data presented herein cover the greater part of the period of destructive activity.

GLADIOLUS THRIPS CONTROL STUDIES AND OBSERVATIONS ON BULB MITE INFESTATION[1]

By F. L. GAMBRELL,[2] *New York State Agricultural Experiment Station, Geneva, N. Y.*

The gladiolus thrips (*Taeniothrips gladioli* M. and S.) was first noticed as being injurious to gladiolus in New York during 1931. During that season its distribution and most serious injury appeared to be limited principally to central and western New York. This insect has now be-

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 27, Jan. 2, 1934.

[2]The writer wishes to acknowledge the assistance of Mr. R. J. Kowal, temporary assistant, in conducting these experiments.

come generally distributed thruout the state and has caused considerable damage in both commercial and home plantings. Because of the wide distribution of gladiolus corms and plants by commercial growers and the ability of the insect to overwinter and propagate on corms in storage, under favorable conditions, this pest is now found in many different sections of the country.[3]

During the past season experiments were conducted relative to the control of gladiolus thrips, both with respect to corm treatments and control measures in the field. Approximately 13,000 corms of the variety Mrs. Francis King were used in these studies. Briefly, the work included corm treatments, insecticides applied in furrow at the time of planting, weekly applications on the surface of the soil, weekly dusts and weekly sprays. Planting was begun on June 26 and finished on June 30. Details as to dilutions and extent of treatments are given in Table 1.

Plan of Experiments.—The field was divided into seven sections extending 20 feet parallel with the row and 135 feet across the row. Each section was subdivided into five plats 20 feet long and 15 feet wide which included six rows 20 feet in length and three feet apart. Every plat was separated from the other plats by a barrier 10 feet wide. The treatments were arranged as follows: Section 1, corm treatments; Section 2, insecticides applied in furrow at planting time; Section 3, weekly soil treatments; Section 4, weekly dusts; Section 5, weekly sprays; Sections 6 and 7, checks consisting of infested and uninfested corms. All corms used in the treated plats were uniformly infested prior to planting. Field treatments were begun on July 13 and repeated weekly until September 15, making a total of ten applications.

Discussion of Results.—An examination of corms which received treatment prior to planting showed that most of the materials were effective in killing larvae and adults of the thrips. However, some treatments failed to materially reduce the thrips population on the corms, which resulted in injury to the flowers later in the season. Such materials as naphthalene, mercuric chloride and calcium cyanide, as demonstrated by other workers[4] and also in experiments conducted by the writer[5], afforded a high degree of kill of overwintering thrips. In the field

[3]Weigel, C. A., and Smith, F. F. The present status of the gladiolus thrips in the United States. Jour. Econ. Ent., vol. 26, No. 3, pp. 523–528. 1933.

[4]Smith, F. F., and Richardson, H. H. Preliminary report on the control of the gladiolus thrips on corms in storage. Jour. Econ. Ent. vol. 26, No. 3, pp. 536–545. 1933.

[5]Gambrell, F. L. Corm Treatments for the Control of Gladiolus Thrips. Mimeograph: New York Agr. Exp. Sta. March, 1933.

experiments it appears that the extended hot, dry period which continued for several weeks after the corms were planted materially retarded the sprouting of corms and apparently afforded favorable conditions for the development of other pests, particularly the bulb mite

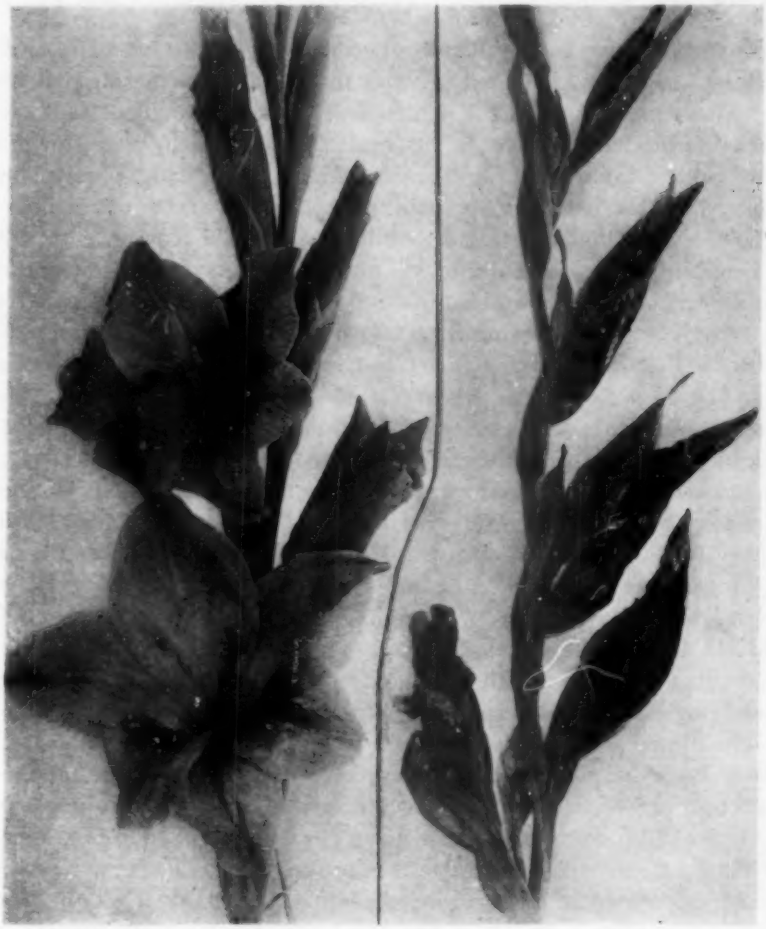

FIG. 140.—1. Healthy flowers; 2. Flower injured by gladiolus thrips.

(*Rhizoglyphus hyacinthi*.) On the contrary the population of thrips appeared to be materially reduced and it was not until late in the season that the numbers were sufficiently abundant to cause noticeable injury (Figure 140, 2), even on the untreated plants. In view of this fact it is

the opinion of the writer that further experiments are necessary to demonstrate fully the efficiency of corm and field treatments for the control of gladiolus thrips under New York conditions, despite the fact that wide differences exist between the amount of salable flowers on untreated plants and some of those which received corm or field treatments (Table 1).

Records relative to sprouting and growth of plants were made during the first few weeks after planting with the idea of determining the effect of treatments, if any, on the plants. It soon became evident that there was considerable variation in the rapidity of sprouting and growth of plants in the different sections of the field. Likewise, many plants barely broke thru the surface of the soil before they began to turn yellow or yellowish brown in color and die while others would grow several inches in height and then the outer leaves and tips would turn yellow and the plants eventually die. An examination of such plants revealed the fact that the corms were being attacked by the bulb mite (*Rhizoglyphus hyacinthi*) (Fig. 141, 3), and also that some were infected with disease Fig. 141, 2). Since the injury from these mites was evident on a large number of the plants in certain plats and because many corms failed to sprout, it seemed worth while to examine the entire planting for the presence of mites and the extent of injury apparently caused by them. It was found that the sprouts on many of these corms had been killed before they had broken thru the surface of the soil. An examination of plants that appeared to be unhealthy frequently showed that the corm was badly injured or practically destroyed by this pest (Fig. 141, 4). During the remainder of the season the plants were examined at regular intervals and those which showed evidence of turning brown and dying were removed and records kept of those showing injury.

The injury produced by the bulb mite may be roughly divided into three classes; namely, old corm, new corm, and plant stem injury. From our observations it is apparent that the greater part of the injury occurs upon the old corms, either upon the upper or basal portion of the corm. When the basal portion is affected the root system is destroyed or greatly diminished early in the growing season of the plant. This, of course, affects the normal growth of the plant and death usually results. Another kind of injury, but less common, is that in which the mites attack the young or developing corm. This injury frequently results in the death of the plant. In some cases the mites migrate or extend their feeding area into the stem of the plant immediately above the point where it is attached to the young corm. This latter type of injury is not so common as that described above. Certain diseases are apparently associated

TABLE 1. FOLIAGE DEVELOPMENT, MITE AND THRIPS INJURY AS RELATED TO CORM AND FIELD TREATMENTS

Treatment	Dilution or Temperature	Duration	Mite injury		Flower injury		Average height of foliage at maturity inches
			Percentage corms killed	Percentage plants killed	Percentage salable flowers	Percentage unsalable flowers	
Corm treatments prior to planting							
Lime-sulfur	1–8	48 hrs.	5.00	1.66	80.00	20.00	29.95
Cold storage	35°–38° F	2 weeks	5.83	18.33	83.79	16.21	28.81
Mercuric chloride	1–1000	15 hrs.	6.66	22.50	80.44	19.56	30.10
Hot water	116° F	20 mins.	10.00	41.66	78.95	21.05	28.22
Cold water	tap	48 hrs.	11.66	56.66	75.00	25.00	29.05
Nicotine dust	2 per cent	2 weeks	11.66	10.00	71.90	28.10	27.77
Naphthalene, chipped	1 lb. to 1 bu.	2 weeks	11.66	30.00	51.73	48.27	29.59
Lime-sulfur-nicotine	1–8, 1–400	48 hrs.	12.50	12.50	80.00	20.00	28.17
Tobacco dust	1 per cent	2 weeks	12.50	44.16	80.00	20.00	27.92
Naphthalene, flakes	1 lb. to 1 bu.	2 weeks	17.50	25.00	88.89	11.11	27.78
Calcium cyanide	5 ozs.–1000 cu. ft.	2 fumigations*	18.33	40.00	76.94	23.06	28.44
Naphthalene, crude	1 lb. to 1 bu.	2 weeks	19.16	12.50	82.15	17.85	29.52
Sulfur dust	1 lb. to 1 bu.	2 weeks	20.00	33.33	25.52	76.48	25.85
Copper cyanide	5 lbs–100 gals.	48 hrs.	20.83	56.66	14.29	85.71	25.94
Applied in furrows with corms at planting time							
Naphthalene, crude	500 lbs. per acre	1 application	10.55	1.11	16.67	83.33	22.69
Naphthalene, flakes	500 lbs. per acre	1 application	22.22	1.11	No blooms developed		19.33
Tobacco dust	500 lbs. per acre	1 application	25.00	31.11	53.85	46.15	24.98
Sulfur dust	500 lbs. per acre	1 application	47.77	30.00	No blooms developed		22.66
Foliage sprays							
Nicotine-casein	1–800, 1–100 gals.	10 applications	20.27	34.16	64.00	36.00	28.36
Paris green-brown sugar	4 lbs., 66 lbs.–100	10 applications	30.55	48.61	95.66	4.34	25.44
Pyrethrum extract	1–800	10 applications	49.72	40.00	No blooms developed		21.46
Summer oil	1 per cent	10 applications	56.38	34.44	No blooms developed		22.05
Lime-sulfur	1–40	10 applications	73.61	23.05	No blooms developed		20.14
Check—No treatment	———	———	65.75	25.83	17.10	82.89	23.39

*Two fumigations at weekly intervals.

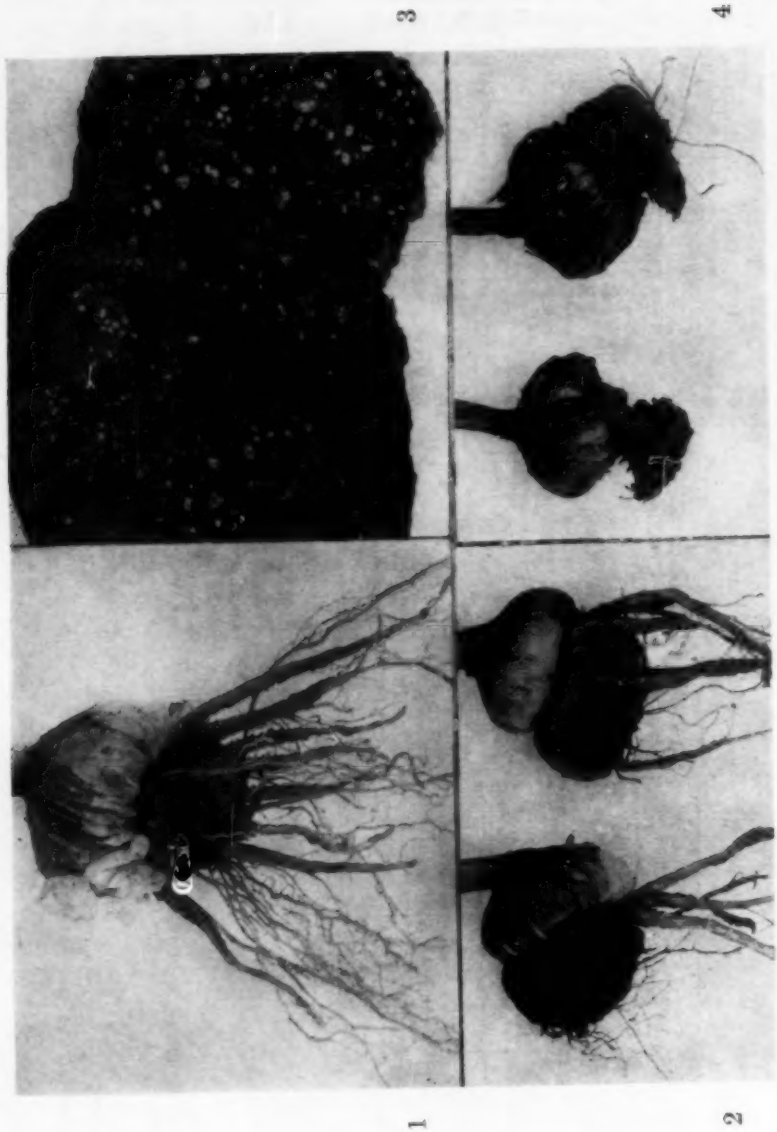

FIG. 141.—1. Root system and development of corm of healthy plant; 2. Root system and development of corms affected with disease; 3. Portion of inside of corm (enlarged) showing mites; 4. Root system and development of corms which have been injured by the bulb mite.

with mite injury and are no doubt responsible for some damage to plants. Where corm treatments were used for the control of the gladiolus thrips the amount of injury to plants and corms by the bulb mite was considerably less than that of untreated corms and suggests that such treatments may have materially reduced the amount of damage (Table 1). While there appears to have been a material benefit derived, that is in the reduction of injury to plants and corms from the use of certain of the above mentioned materials, further studies are necessary to determine the exact status of the mite in relation to injury; also, whether there is a definite correlation between the amount of injury which resulted and the treatments employed in these tests.

EFFECT OF TREATMENTS ON CORMS AND PLANTS.—In considering the influence of treatments for the control of the gladiolus thrips upon the bulb mite, as well as the effect of insecticides on the corms and plants, it should be pointed out that a very hot, dry period prevailed for several weeks after planting which may have been partially responsible for the degree of control obtained and also for the amount of injury incurred. Perhaps the most striking feature with reference to treatments was the effect of paradichlorobenzene upon corms. This material was used at the rate of one ounce to 100 corms, or roughly at the rate of one pound per bushel. The corms were placed in double paper bags and the correct amount of material sifted among them. The bags were then tied as tightly as possible and were kept closed for two weeks. The same procedure was followed for all of the insecticides which were used in dry form for corm treatments. After two weeks' exposure the corms which were treated with paradichlorobenzene were very brown in color, quite soft, and only 16 per cent of them sprouted. When this material was placed in contact with the corms or in the furrow after the corms were partially covered at time of planting sprouting was reduced to about 3 per cent. In the case of corm treatments with naphthalene no injury was observed, altho there was a very noticeable retardation of growth particularly when naphthalene was placed in the furrow with the corms. Two months after planting only 8 per cent of the corms treated with flake naphthalene in the furrow and only 28 per cent of those treated in like manner with crude naphthalene showed signs of growth. Mercuric chloride dip apparently caused slight retardation in early growth. The injury resulting from weekly applications of crude naphthalene, flake naphthalene or paradichlorobenzene at the rate of 500 pounds per acre per application on the soil around the plants was less severe, altho there was some evidence of burning on the foliage and plant stems at the surface of the ground. This was more noticeable on plants treated with

paradichlorobenzene, particularly during hot, dry weather. No injurious effects were observed from repeated applications of dust or spray mixtures, with the possible exception of the Paris green-brown sugar spray in which some of the older and lower leaves were killed. It was observed, however, that plants sprayed with Paris green-brown sugar or the nicotine-casein mixtures were larger than those on other sprayed plats, and also the injury by thrips and mites was less.

TECHNIQUE OF FIELD EXPERIMENTATION IN ENTOMOLOGY I. SOME PRINCIPLES INVOLVED IN A WELL-PLANNED EXPERIMENT

By L. L. HUBER and J. P. SLEESMAN, *Ohio Agricultural Experiment Station*

In discussing experimental technique before the American Association of Economic Entomologists in 1932, J. S. Houser gave as his opinion that "it can be stated with assurance that a technique should be followed which conforms to biometric principles in order that the results obtained may be subjected to statistical analysis." It is not the present purpose to defend this statement, for it needs no defense; nor is it purposed to urge its acceptance, for it is being accepted. It is rather our purpose to show, thru our own experiences, how biometric principles have been used to advantage in our own researches. Just as in the days of Dr. S. A. Forbes, there are methods "ready made to our hands, and which we have only to appropriate and adapt to our ends." The methods suggested by Fisher and others have been found to be particularly adaptable to field experimentation in entomology. This paper is a brief summary of some of the more important concepts which the economic entomologist should constantly keep in mind. Papers to follow will deal concretely with the principles set forth here.

1. *Do all experiments require statistical analysis?* In exceptional cases small experiments which exhibit wide differences in treatments may be evaluated by a simple examination of the data. However, it is well to remember that, unless statistical analysis is employed, two or more investigators working on the same problem will not necessarily draw the same conclusions. Failure to observe uniform and valid methods of analysis of data tends to lead to vague and inaccurate presentation of results, the inevitable consequence of which is confusion.

2. *What are the fundamental requirements which govern all well-planned experiments?* The first requirement is that the experiment be planned in such manner that it shall yield a comparison of different treatments.

The treatment may be sprays, varieties, rate of application of spray, or other measurable variables. The second requirement is that the experiment shall provide a means of testing the significance of such differences as are observed. These requirements mean that all treatments must be, at least, duplicated, although further replication is desirable.

3. *What is the greatest source of error in field experimentation in entomology?* The greatest source of error in entomological experiments lies in the location or position of the plots. A heterogeneous soil, an uneven distribution of insects, etc., are elements contributing to variation due to location.

4. *Is it to be understood that homogeneity in location of plots, even under unusually uniform conditions, can never be assumed?* In field experiments it is never safe to assume that location is homogeneous.

5. *How may heterogeneity of position be overcome?* In theory, heterogeneity may be overcome by replication. Infinite replication, however, is a physical impossibility. Moreover, due to the inclusion of the wider range of soil variation, much of which is not random, the experimental error is not reduced as much as theory would indicate.

6. *What is meant by "experimental error"?* The total variability in an experiment may be divided into two portions; namely, variability due to controlled factors and that due to uncontrolled or unknown factors. The variability due to location and treatments for the most part falls into the first group. The difference between the variability in the experiment as a whole and that due to location and treatment is known as experimental or random error.

7. *What is the purpose of replication?* Replication is designed to serve two purposes: (a) It reduces the experimental error, and (b) it provides an estimate of the size of this error. Without replication there can be no comparison of replicates, and without this comparison there can be no standard with which to compare the observed differences in treatments.

8. *Is it to be understood that an experiment without replication is without value?* In experiments with non-replicated treatments, single plots, generally large, are used. Unfortunately, such plots do not lend themselves to statistical treatment; hence, an experiment so designed is of doubtful value. The interpretation of the data from single plot treatments necessitates too much speculation.

9. *Assuming that experimental design is to be developed in accordance with the principles mentioned above, what are the simplest methods of layout which fulfill the conditions of supplying a valid estimate of experimental error and of eliminating the larger portion of heterogeneity due to location?*

The method of randomized blocks and the method of Latin square are the most highly favored, but not the only, methods. Of the two, the first method is the simpler, for it is more easily adjusted to the majority of field experiments.

10. *What is meant by the randomized block method and what are its advantages?* The answer to this question may be approached more or less indirectly by assuming a problem designed to test the differences between six treatments. According to the ideas of the individual experimenter, this test might be set up something as follows:

Design No. 1. Showing single, non-replicated plots

1 2 3 4 5 6

Design No. 2. Showing each treatment replicated four times. The replications are systematic

1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

Design No. 3. Showing treatments replicated four times with unrestricted random distribution of plots

1 4 2 3 6 4 6 1 3 4 1 5 1 5 3 6 2 4 5 3 2 6 5 2

Design No. 4. Showing treatments replicated four times with restricted random or randomized block arrangement of plots

1 2 3 4 5 6 3 1 4 6 2 5 4 6 3 1 5 2 3 4 5 6 2 1

The single plot arrangement, as in Design No. 1, is wholly inadequate. Systematic replication, as in Design No. 2, is better than the single plot method, but, even so, it will not permit the calculation of a valid estimate of experimental error. Design No. 3, unrestricted random distribution of plots, permits a valid test of experimental error, although the error will usually be larger than necessary. Very few investigators use this method. The superiority of Design No. 4 lies in the fact (a) that differences in location between whole blocks may be eliminated from the comparison between treatments because of the placing of one replicate of each treatment into each block, and (b) that the errors due to location differences between plots in the blocks can be estimated when, and only when, the different treatments are arranged in blocks wholly at random. This method allows not only an accurate measure of experimental error but eliminates a still greater part of the variation due to location.

11. *What is the Latin square method?* With this method of experimentation the plots are arranged with as many replicates of each treatment as there are treatments. Each treatment appears once, and only once, in each column and each row. The Latin square method is the randomized block method with an additional restriction.

12. *What are the advantages and disadvantages in the use of the Latin square method?* The chief objection to the Latin square method is that

its use is difficult when more than six or seven treatments are being tested. The advantages of its use lie primarily in the fact that it ordinarily provides for more accurate comparisons. The restrictions placed on the distribution of plots in the randomized block method are increased with the Latin square method. The elimination of location differences between the columns and rows increases the value of an experiment as a means of detecting treatment differences.

13. *What relation does adequate sampling bear to proper experimental technique?* The sampling error is a component part of experimental error; hence, increased accuracy in sampling leads to a more accurate estimate of the experimental error. When the limit of replication has been reached and still more accuracy is desired, it is well to re-examine sampling methods.

14. *How many samples are necessary from a single plot?* The estimate of sampling error is derived from the variation between sampling units, and, in order that an estimate of error may be made, at least two sampling units must be taken per plot. The sampling units must be distributed at random in the plot and may consist of one or more parts. The size of the sampling error is influenced by the number and distribution of units within the sampling unit.

15. *What are the marks of a good sample?* (a) The sample must be large enough and so distributed in the plot as to be representative of the whole plot. (b) The sampling must be carried out in such manner as to make possible a valid estimate of the error introduced in taking the sample. Unless an estimate of error can be made, the validity of the conclusions drawn from the observations on the sample remains in doubt.

16. *How can we determine the size of sample to be taken?* The size can be determined only by direct experiment. However, the size will depend upon the biological and physical considerations of the problem to be solved. If the size of a sample is reduced, the sampling error will be increased with a consequent loss of accuracy; but, since the sampling error can always be calculated, there is no danger of drawing unwarranted conclusions.

17. *If two or more experiments of the same type are to be conducted at different points, should they be similarly planned?* If the data are to be subjected to analysis as a composite whole, such experiments should be alike in that they contain the same number of treatments, the same rate of treatment, etc. They should also have the same experimental design. However, the random arrangement of plots should be different in each experiment. On the other hand, if the data are not to be subjected to analysis as a composite whole, the number of treatments, rate of treat-

ment, etc., need not be identical. The essential requirement, as mentioned above, is that the experiment be so planned that the investigator can make a valid estimate of the experimental error.

18. *What shall be the size of plots?* The size of plots is a matter that must be left largely to the judgment of the investigator.

It should be pointed out that other important questions might be discussed. It is our belief, however, that a better understanding of the principles mentioned above would, to say the least, appreciably reduce the confusion that now exists in the interpretation of experimental data.

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THE SYNERGISTIC EFFECT OF THE CHLORIDES AND BICARBONATES OF POTASSIUM AND SODIUM UPON THE PARALYTIC ACTION OF NICOTINE IN THE COCKROACH[1]

By Norman D. Levine and Charles H. Richardson, *Iowa State College, Ames, Ia.*[2]

No work with which we are acquainted has been done on the synergistic action of inorganic salts on the toxicity of nicotine to insects, although it is possible that this action might be utilized in the practical control of insect pests. Salant and Washeim (5) found that when the isolated frog heart was perfused with various solutions of nicotine in Ringer's solution, an excess of potassium chloride, or a deficiency of calcium chloride in the Ringer's solution, increased the toxicity of the nicotine, and that an excess of calcium chloride diminished the effect of the nicotine. Nicotine dissolved in solutions of single salts could not be used, however, because those solutions alone would have a marked influence on the action of the heart.

[1]Contribution from the Department of Zoology and Entomology.

[2]The writers are indebted to Mr. G. L. Bond for assistance in the preliminary phase of this investigation.

Considerable attention has been given to synergistic action in the local anesthetics, and recently Hirschfelder and Bieter (3) have reviewed the literature in this field. They state that solutions of potassium sulphate definitely increase and prolong the local anesthetic action of cocaine and novocaine on intracutaneous injection into man, and append to their work a bibliography on the synergistic effect of various inorganic and organic compounds upon the action of local anesthetics. Rider (4), in a paper which is not included in the above bibliography, found that potassium chloride solutions as well as solutions of ammonium chloride and magnesium chloride increase the anesthetic action of cocaine on the sciatic nerve of the frog.

MATERIALS AND METHOD.—In the present investigation, adults of the American cockroach, *Periplaneta americana* (L.), were used as test animals. They were injected with nicotine solutions of various concentrations made up in (1) 0.1 M. potassium chloride, (2) 0.1 M. potassium bicarbonate, (3) 0.1 M. sodium bicarbonate, (4) 0.1 M. sodium chloride, and (5) distilled water (the control). Ten roaches were usually treated with each concentration of nicotine in each solvent. The concentrations of the nicotine solutions ranged from 0.01 per cent (grams per 100 cc.) down to one from which no effect was observed. For distilled water and sodium chloride, this concentration of nicotine was 0.001 per cent; for sodium bicarbonate, 0.0005; for potassium bicarbonate, 0.0004; and for potassium chloride, 0.0001 per cent. Other controls were also injected with solutions of the salts alone. In the case of the potassium bicarbonate solution, a slight effect was observed in three roaches, but there was none with the solutions of the other salts.

The roaches were injected by a modification of a method developed by Yeager, Woolley and Brown (6). A micropipette holding 0.1 cc. of liquid and calibrated in hundredths of a cubic centimeter was used. To the delivery end a hypodermic needle was attached by a short piece of rubber tubing; to the other end a short piece of glass tubing which served as a mouthpiece was attached by a long rubber tube. A rubber stopper was fitted around the pipette and the apparatus was fastened horizontally to a ringstand by a clamp which grasped the stopper. A similar injection apparatus for insects has been described by Campbell (1). The roach was injected through the conjunctiva at the distal end of the coxa of the hind leg, 0.05 cc. of solution being delivered in every case.

CRITERION OF EFFECT.—After injection, the roach usually crawled in a normal manner for some seconds except for a tendency to use the injured leg less than the others. In some instances there was a slight stimu-

lation. Paralysis of the legs followed in from ten to forty-five seconds, involving first the hind legs, which were dragged when walking, then the hind two pairs of legs, and finally the front pair. Recovery began after a certain time, the use of the legs being regained in the reverse order; some minutes later it was practically complete. Paralysis from solutions containing the lower concentrations of nicotine was usually incomplete, only the hind legs, or the middle and hind legs being affected.

The duration of complete paralysis and the interval from injection to recovery were noted, as also was the extent of incomplete paralysis in the cases where it occurred.

As a criterion of the effect of an injection, the time for complete recovery seemed impractical because it was usually difficult to determine the instant when the effect of the nicotine ceased and the roach recovered. It was, therefore, decided to use the duration of paralysis as the criterion of effect, and to set up for this purpose a numerical scale which would express the extent of paralysis as well as its duration. The following scale was adopted:

0. No effect.
1. Paralysis of hind pair of legs.
2. Paralysis of hind two pairs of legs.
3. Complete paralysis lasting up to ¼ minute.
4. Complete paralysis lasting ¼ to ½ minute.
5. Complete paralysis lasting ½ to 1 minute.
6. Complete paralysis lasting 1 to 2 minutes.
7. Complete paralysis lasting 2 to 4 minutes.
8. Complete paralysis lasting 4 to 8 minutes.

This series, in which time forms a sort of geometrical progression, is used in Chart 1 and Table 1 to express the relative duration of paralysis. It enables one to compare satisfactorily the results obtained from the high and the low concentrations and to subject them to statistical treatment.

RESULTS. The effects of the different salts on the toxicity of the nicotine are shown graphically in Chart 1. Each point on the graphs represents the mean effect of a solution on nine or ten (in most cases, the latter) individuals. In each graph, the control, nicotine dissolved in distilled water, is included for comparison. The concentration of nicotine has been placed on a logarithmic scale, and the numbers denoting relative duration of paralysis on an arithmetical scale, but it must be remembered that the latter represent a kind of geometric relationship to the actual duration of paralysis.

The differences between the means obtained at the same concentration of nicotine in the various salt solutions have been tabulated (Table 1)

and inspected statistically with regard to their significance by a method of comparison of means of small samples (Fisher 2). In computing these differences, the mean relative duration of paralysis of any solution arranged vertically in the table is subtracted from one arranged horizontally. Thus the mean for a 0.004 per cent solution of nicotine in 0.1 M. potassium chloride is greater by 1.8 than that for the corresponding solution of nicotine and sodium chloride and smaller by 2.8 than the mean of the comparable solution of nicotine and potassium bicarbonate. In those cases where the mean of a vertically arranged solution is the greater, the difference is preceded by a minus sign. An asterisk indicates that the difference is probably significant.

TABLE 1. DIFFERENCES BETWEEN MEANS OF RELATIVE DURATIONS OF PARALYSIS FOR THE DIFFERENT SOLUTIONS

Concn. of nicotine per cent	Solvent (0.1 N.)	$KHCO_3$ (0.1 M.)	$NaHCO_3$ (0.1 M.)	NaCl (0.1 M.)	Distilled water
0.01	KCl	0.1	0.3	1.1	2.7*
	$KHCO_3$		0.2	1.0	2.6*
	$NaHCO_3$			0.8	2.4*
	NaCl				1.6*
0.004	KCl	—2.8*	—0.6	1.8*	1.5*
	$KHCO_3$		2.2*	4.6*	4.3*
	$NaHCO_3$			2.4*	2.1*
	NaCl				—0.3
0.002	KCl	—3.1*	1.1	2.0*	1.7*
	$KHCO_3$		4.2*	5.1*	4.8*
	$NaHCO_3$			0.9*	0.6
	NaCl				—0.3
0.001	KCl	—3.4*	0.1	0.9*	0.9*
	$KHCO_3$		3.5*	4.3*	4.3*
	$NaHCO_3$			0.8*	0.8*
	NaCl				0.0
0.0005	KCl	0.6	1.3*		
	$KHCO_3$		0.7*		
0.0004	KCl	0.7*			

*Difference is statistically significant.

From the graphs (Figure 142) and Table 1, it will be seen that nicotine alone produced an effect on the roaches in a concentration of 0.002 per cent, but not lower. At 0.01 per cent complete paralysis was produced which lasted, on the average, about a quarter of a minute. At all lower concentrations the mean effect was incomplete paralysis, until, at 0.001 per cent, no effect was manifest.

When the nicotine was dissolved in 0.1 M. sodium chloride solution, the effect on the roach was not significantly different from the above except at the nicotine concentration of 0.01 per cent. Here paralysis lasted between one-fourth and one-half minute.

In 0.1 M. sodium bicarbonate solution, nicotine usually produced paralysis of the hind pair of legs at a concentration of 0.001 per cent.

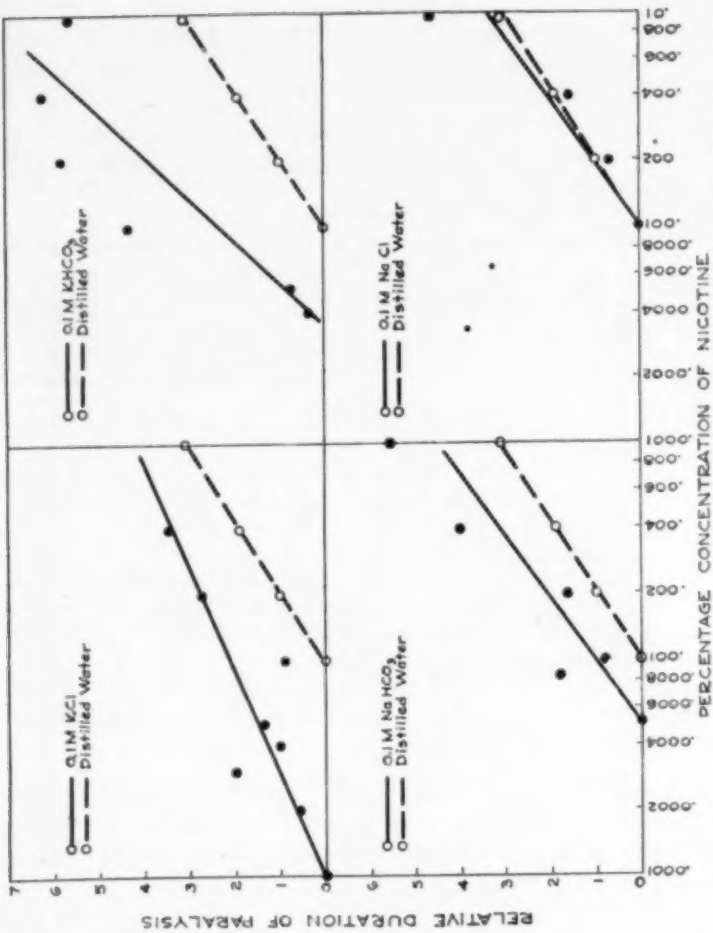

FIG. 142.—Relative duration of paralysis in the American cockroach after injection of nicotine in solutions of potassium chloride, potassium bicarbonate, sodium chloride, sodium bicarbonate and distilled water.

When it was diluted to 0.0005 per cent, no effect was noticeable. At the higher concentrations, the salt distinctly increased the toxicity of the nicotine.

Dissolved in 0.1 M. potassium bicarbonate solution, nicotine produced a slight effect on the roaches at a concentration of 0.0005 per cent, whereas at 0.0004 per cent an effect equivalent only to that of the salt solution alone was observed. However, at concentrations of 0.001 to 0.004 per cent, the toxicity of the nicotine was increased more than by any other salt used in these experiments.

Nicotine produced a distinctly greater paralytic activity in 0.1 M. potassium chloride solution at lower concentrations of the alkaloid than in solutions of any of the other salts, effects being noticeable at nicotine concentrations of 0.0004, 0.0003, and 0.0002 per cent. Only when the concentration of nicotine was reduced to 0.0001 per cent did its effect vanish. On the other hand, no statistical difference in effect from that of potassium bicarbonate solution was found at 0.0005 per cent nicotine concentration, and at all higher concentrations of nicotine, with the exception of 0.01 per cent, the potassium chloride produced a significantly smaller increase in toxicity of the nicotine.

It is interesting to note that in 0.01 per cent nicotine solution no significant difference between the effects produced by any of the salts could be detected although the mean paralytic times were always significantly greater than that produced by 0.01 per cent nicotine in distilled water.

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INSECTICIDAL TESTS OF SYNTHETIC ORGANIC COMPOUNDS —CHIEFLY TESTS OF SULFUR COMPOUNDS AGAINST CULICINE MOSQUITO LARVAE

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The insecticidal effectiveness of certain types of aliphatic sulfur compounds, especially thiocyanates, isothiocyanates, mercaptans, and disulfides[1, 2] led the Insecticide Division of the Bureau of Chemistry and Soils to prepare organic sulfur compounds of various other types. These and certain synthetic organic compounds not containing sulfur were tested chiefly against culicine mosquito larvae to discover compounds worth testing against other species of insects. The results here presented may be suggestive in the search for substitutes for lead arsenate.

Larvae of *Culex pipiens* L. and *C. territans* Walk. from Takoma Park, Md., were used during the early fall of 1932. Larvae of *Culex quinquefasciatus* Say. hatched from eggs shipped from Florida were used during the late fall and winter. All methods employed have been described fully[3, 4]. The tests were made in Erlenmeyer flasks containing 100 cc. of distilled water and 50 or 100 third and fourth instar larvae. The temperature was 29.3 ± 0.1°C.

With the exception of one liquid, β-hydroxydiethyl sulfide, which was miscible with water, all compounds reported upon here were solids at room temperatures. Most of them were nearly insoluble in water. Two of the compounds, namely, p-hydroxyphenylacetimido-thiophenylether hydrochloride and phenylacetimido-thio-p-tolylether hydrochloride, are new.

Some standard of effectiveness was needed in order to separate the compounds into promising and unpromising groups. In previous work nicotine at 1: 10,000 was found to kill an average of 65 per cent of the larvae in 8 hours. Since nicotine was only moderately effective as com-

[1]Roark, R. C., and Cotton, R. T. 1930. Tests of Various Aliphatic Compounds as Fumigants. U. S. Dept. Agr. Tech. Bul. 162, 52 p.

[2]Neifert, I. E., Cook, F. C., Roark, R. C., Tonkin, W. H., Back, E. A., and Cotton, R. T. 1925. Fumigation against grain weevils with various volatile organic compounds. U. S. Dept. Agr. Bul. 1313, 40 p.

[3]Campbell, F. L., Sullivan, W. N., and Smith, C. R. 1933. The relative toxicity of nicotine, anabasine, methyl anabasine, and lupinine for culicine mosquito larvae. Jour. Econ. Ent. 26: 500–509.

[4]Jones, H. A., Gersdorff, W. A., Gooden, E. L., Campbell, F. L., and Sullivan, W. N. 1933. Loss in toxicity of deposits of rotenone and related materials exposed to light. Jour. Econ. Ent. 26: 451–470.

pared with rotenone, it was decided to consider unpromising those compounds that were apparently less effective than nicotine and to test again those that were as effective or more effective than nicotine. The initial tests of the compounds being studied were therefore made at 1: 10,000, except in a few cases where it was necessary or desirable to use a lower concentration. The results of these initial tests are given in Table 1.

Of the 68 compounds listed in Table 1, 24 were considered worth testing again at lower concentrations. These compounds were found among the benzothiazoles, disulfides, sulfides, thioethers, and thiophenols. With the exception of the thioethers, which were fairly soluble in water, all promising compounds were soluble in acetone and only slightly soluble in water.

The results of the subsequent tests with the 24 promising compounds will not be given in full. A further reduction in the number of compounds to be studied more carefully was made by eliminating those that failed to kill 50 per cent of the larvae overnight at 1: 40,000 (11 of the 24). Those that remained were diphenylene oxide, diphenylene sulfide, 2-phenylbenzothiazole, p-thiocresol, β-thionaphthol, p-bromthiophenol, 2-phenyl tetramethylene 1, 3-disulfide, diphenyl sulfone, and first five thioethers listed in Table 1.

In Table 2 are given the results of simultaneous tests at 1: 40,000 of all the compounds just mentioned except diphenylene oxide and thioethers Nos. 1286 and 1287, which were received later. The compounds are listed in order of effectiveness. The appearance of the liquid in the flasks is described in order to show that the larvae were exposed to solid particles variously dispersed and distributed in the flasks. The question arose as to whether these particles contributed to the effect observed. Accordingly the six most effective compounds that were relatively insoluble were tested again at 1: 40,000 and clear filtrates from duplicate flasks were tested at the same time. The results are given in Table 3. All filtrates were very effective, some being as effective as the unfiltered liquid. Since the larvae were being affected chiefly by dissolved material, and since only a small fraction of the solids were in solution at 1: 40,000, it followed that some of the compounds should be highly effective at much lower concentrations. All six compounds were therefore tested again at 1: 100,000 and 1: 200,000 in comparison with rotenone. The results are given in Table 4.

At these lower concentrations, the order of effectiveness was different from that in Table 2. Diphenylene sulfide emerged as the most toxic sulfur compound the writers had tested against mosquito larvae up to

TABLE 1. RESULTS OF INITIAL TESTS OF SYNTHETIC ORGANIC COMPOUNDS AGAINST MOSQUITO LARVAE

Name of compound	Insecticide division number	Source[1]	Application[2]	Concentration in water[3]	Solid particles visible in water	Per cent mortality in 18 to 24 hours	Retested
Benzothiazoles							
2–Phenylbenzothiazole	1159	H. L. Haller	A	1:10,000	Yes	68	Yes
6–Chloro–2–phenylbenzothiazole	1158	H. L. Haller	A	1:10,000	Yes	88	Yes
2–Phenyl–5–chlorobenzothiazole	1157	H. L. Haller	A	1:10,000	Yes	76	Yes
2–(3, 5) Dinitrophenylbenzothiazole	1156	H. L. Haller	I	1:10,000	Yes	4	No
2–Mercaptobenzothiazole	1246	Commercial	A	1:10,000	Yes	88	No
Disulfides							
Di–o–Aminophenyl disulfide	1160	H. L. Haller	A	<1:10,000	Yes	100	Yes
Dibenzyl disulfide	1111	L. E. Smith	A	1:10,000	Yes	>25[4]	No
Di–p–nitrophenyl disulfide	1183	L. E. Smith	A	<1:10,000	Yes	0	No
Diphenyl disulfide	1114	Commercial	A	1:10,000	Yes	>60	No
2–Phenyl–tetramethylene–1, 3–disulfide	1128	L. E. Smith	A	1:10,000	Yes	100	Yes
2, 2–Diphenyl–tetramethylene–1, 3–disulfide	1110	L. E. Smith	A	1:10,000	Yes	>10	No
Di–2–nitro–4–chlorophenyl disulfide	1162	H. L. Haller	I	1:10,000	Yes	0	No
Phenyl dithiodiazolone disulfide	1281	L. E. Smith	A	1:260,000	Yes	0	No
Trimethylene disulfide	1112	L. E. Smith	I	1:10,000	Yes	0	No
Sulfides							
Diphenylene sulfide	1142	L. E. Smith	A	1:10,000	Yes	100	Yes
β–Hydroxydiethyl sulfide	1322	N. L. Drake	W	1:10,000	No	0	No

[1]In this column are given the names of the men who prepared the compounds. All but R. Hann are in the Insecticide Division, Bureau of Chemistry and Soils. "Commercial" indicates that the compound was purchased on the open market.

[2]In this column "A" indicates that the compound was added to water in acetone solution. Not more than 0.3 cc., usually 0.15 cc., of acetone solution was added to 100 cc. of water. As a rule the compound so added precipitated out in water to some extent as indicated in column 6. "W" indicates that the compound was tested in aqueous solution without acetone. "I" indicates that the compound was so slightly soluble in both acetone and water, that it was added to water in solid form, 10 mg. to 100 cc.

[3]This expression applies to the total quantity of the compound added to water, whether in suspension or in solution or both.

[4]In a few cases indicated by the "greater than" sign the duration of the test was only 9 hours. It may be assumed that the mortality would have been greater if the tests had run over night.

Thioethers							
Benzimido–thiophenylether hydrochloride	1109	L. E. Smith	W	1:10,000	No	100	Yes
Phenylacetimido–thiophenylether hydrochloride	1126	L. E. Smith	W	1:10,000	No	100	Yes
p–Hydoxyphenylacetimido–thiophenylether hydrochloride[5]	1286	L. E. Smith	W	1:100,000	No	56	Yes
Phenylacetimido–thio–p–tolylether hydrochloride[6]	1287	L. E. Smith	W	1:100,000	No	95	Yes
2, 4–Dihydroxybenzimido–thiophenylether hydrochloride	1178	L. E. Smith	I	1:10,000	Yes	100	Yes
2, 4, 6–Trihydroxybenzimido–thiophenylether hydrochloride	1184	L. E. Smith	I	1:10,000	Yes	22	No
Imido diethylene thiophenylether hydrobromide	1264	F. B. LaForge	W	1:10,000	No	48	Yes
Thiophenols							
o–Aminothiophenol hydrochloride	1133	H. L. Haller	A	1:10,000	Yes	91	Yes
p–Aminothiophenol hydrochloride	1274	L. E. Smith	W	1:40,000	No	2	No
2–Amino–4–chlorothiophenol hydrochloride	1163	H. L. Haller	A	1:10,000	Yes	82	Yes
p–Bromthiophenol	1161	L. E. Smith	A	1:10,000	Yes	100	Yes
p–Nitrothiophenol	1180	L. E. Smith	A	1:10,000	Yes	100	Yes
p–Thiocresol	1230	Commercial	A	1:10,000	Yes	100	Yes
β–Thionaphthol	1245	Commercial	A	1:10,000	Yes	100	Yes
Thioureas							
Thiourea	1232	Commercial	W	1:10,000	No	8	No
Allylthiourea	1241	Commercial	W	1:10,000	No	16	No
Phenylthiourea	1238	Commercial	W	1:10,000	No	2	No
Sulfonic acids and derivatives							
o–Aminophenol p–toluene sulfonate	1267	H. L. Haller	W	1:10,000	No	0	No
Aniline p–toluene sulfonate	1270	H. L. Haller	W	1:10,000	No	2	No
Anthranilic acid p–toluene sulfonate	1268	H. L. Haller	W	1:10,000	No	2	No
α–Naphthylamine p–toluene sulfonate	1269	H. L. Haller	W	1:10,000	No	34	No
Sulfanilic acid p–toluene sulfonate	1266	H. L. Haller	W	1:10,000	No	4	No
o–Aminobenzene sulfonic acid	1240	Commercial	W	1:10,000	No	6No	
1, 8 Dihydroxynaphthalene–3, 6–disulfonic acid	1242	Commercial	W	1:10,000	No	2	No
4–Nitrochlorobenzene–2–sulfonic acid	1237	Commercial	W	1:10,000	No	4	No

[5]Prepared by the general method described by Borsche, W., and Niemann, J. Ber. Deut. Chem. Gesell. 62B: 1743–1745. 1929. M.P. 188°C. Checked by analysis.

[6]Also prepared as cited above. M.P. 153°–155°C. Checked by analysis. Probably the most effective of the thioethers here listed.

TABLE 1. *Concluded*

Name of compound	Insecticide division number	Source	Application	Concentration in water	Solid particles visible in water	Per cent mortality in 18 to 24 hours	Retested
Naphthalene–1, 5–disulfinic acid	1303	H. L. Haller	W	1:10,000	Yes	20	No
Naphthalene–2, 6–disulfinic acid	1302	H. L. Haller	W	1:10,000	No	0	No
Naphthalene 2–6 disulfochloride	1300	H. L. Haller	A	<1:20,000	Yes	6	No
Naphthalene 2–7 disulfochloride	1301	H. L. Haller	A	<1:40,000	No	0	No
Miscellaneous sulfur compounds							
Thioacetamide	1164	H. L. Haller	A	1:10,000	No	20	No
Thiocumazone	1150	E. P. Clark	A	1:10,000	Yes	100	Yes
Thiosemicarbazide	1231	Commercial	W	1:10,000	No	98	No
Phenyl dithio–biazolone mercaptan	1151	R. Hann	A	1:10,000	No	0	No
3, 7–Dimethylthianthrene	1280	L. E. Smith	A	1:40,000	Yes	0	No
Diphenyl sulfone	1115	Commercial	A	1:10,000	Yes	100	Yes
Diphenyl sulfoxide	1108	L. E. Smith	A	1:10,000	No	98	Yes
Tetrathiopentone	1132	H. L. Haller	I	1:10,000	Yes	0	No
Sulfonal	1239	Commercial	W	1:10,000	No	6	No
Trional	1247	Commercial	W	1:10,000	No	8	No
Dithioxalamide	1127	L. E. Smith	A	1:10,000	No	>20	No
Dithiophenyl ethylene	1118	F. B. LaForge	A	1:10,000	Yes	>16	No
2–Thiobenzoxazol	1251	E. P. Clark	A	1:10,000	Yes	26	No
Trimethylgalloyl isothiocyanate	——	J. R. Spies	A	1:10,000	Yes	>12	No
Miscellaneous compounds not containing sulfur							
Diphenylene oxide	1370	L. E. Smith	A	1:10,000	Yes	100	Yes
Carbazole	1477	Commercial	A	1:100,000	Yes	?	No
3, 5–Dinitro–o–cresol	1249	Commercial	A	1:10,000	Yes	100	Yes
p–Nitrophenylacetonitrile	1279	Commercial	A	1:40,000	No	14	No
2, 6–Dimethoxybenzonitrile	1298	H. L. Haller	A	1:20,000	Yes	22	No
2–Methoxy–6–nitrobenzonitrile	1297	H. L. Haller	A	1:50,000	Yes	58	Yes
p–Nitrosodiethylaniline	1278	Commercial	A	<1:40,000	No	30	No
o–Benzoylbenzoic acid	1299	Commercial	A	1:20,000	No	6	No
Dicyandiamidine sulfate	1243	Commercial	W	1:10,000	No	0	No

TABLE 2. COMPARATIVE TESTS AGAINST MOSQUITO LARVAE OF THE MORE TOXIC ORGANIC COMPOUNDS CONTAINING SULFUR. CONCENTRATION 1:40,000. FIFTY LARVAE PER TEST

Name of compound	Appearance of liquid in flasks	Time to kill 25 larvae Min.	Time to kill 50 larvae Min.	Number dead in 8 hours	Number dead in 20 hours
p–Thiocresol	Clear. A few particles on bottom	31	96	—	—
β–Thionaphthol	Slightly turbid. Small particles on bottom, on surface, and in suspension	88	180	—	—
p–Bromthiophenol	Distinctly turbid. Solids in suspensions well dispersed	100	180	—	—
Diphenylene sulfide	Very slightly turbid. Small particles on bottom and surface	155	420	—	—
2–Phenyl–tetramethylene–1, 3–disulfide	Clear. Small particles on bottom and floating in groups on surface	114	—	46	46
Phenylacetimido–thiophenylether hydrochloride	Clear solution	240	—	32	46
Benzimido–thiophenylether hydrochloride	Clear solution	360	—	28	39
2—Phenylbenzothiazole	Distinctly turbid. Small particles on bottom, on surface, and in suspension	330	—	28	36
2, 4–Dihydroxybenzimido–thiophenylether hydrochloride	Clear. Large particles present	—	—	17	30
Diphenyl sulfone	Clear. Small particles on surface and bottom	—	—	20	25

that time. According to Table 4 it is more effective than rotenone, but at still lower concentrations rotenone becomes more effective than diphenylene sulfide.

TABLE 3. RELATIVE EFFECT AGAINST MOSQUITO LARVAE OF AQUEOUS SUSPENSIONS OF SLIGHTLY SOLUBLE SULFUR COMPOUNDS AND CLEAR FILTRATES OF THE SAME CONCENTRATION OF SUSPENSIONS 1: 40,000. FIFTY LARVAE PER TEST

Name of compound	Time to kill 25 larvae (min.) Unfiltered	Filtrate
p–Thiocresol	29	40
β–Thionaphthol	25	126
p–Bromthiophenol	33	31
Diphenylene sulfide	64	74
2–Phenyl–tetramethylene–1,3–disulfide	58	162
2–Phenylbenzothiazole	81	82

The high toxicity for mosquito larvae of the simple sulfur compounds just mentioned raised the question as to whether sulfur was essential to their toxicity. Tests were therefore made at 1: 40,000 comparing p-thiocresol with p-cresol, β-thionaphthol with β-naphthol, and p-bromthiophenol with phenol (p-bromophenol was not available at the time). The sulfur compounds killed more quickly than they did in earlier tests (Table 2), whereas the analogous oxygen compounds, although soluble in water at 1: 40,000, had no effect on the larvae in 20 hours. These tests showed decisively that toxicity of these compounds is enhanced when oxygen is replaced by sulfur. A possible generalization was shattered later, however, when diphenylene sulfide was compared with diphenylene oxide. The oxide proved to be slightly more effective than the sulfide against mosquito larvae. Thinking that toxic properties might reside in the diphenylene group, a test was made of carbazole, which is analogous to diphenylene sulfide and oxide with NH taking the place of S or O. Carbazole, however, had only a slight temporary effect against mosquito larvae at 1: 100,000.

As a result of the foregoing tests against mosquito larvae, diphenylene oxide, diphenylene sulfide, carbazole, and 2-phenylbenzothiazole were selected for tests against other species of insects. Numerical results of these tests will not be given, because the workers who made the tests may wish to publish their data later. It is sufficient to state (Table 5) that a compound was effective or ineffective in order to show that the results against mosquito larvae (Table 4) are not reliable indicators of the toxicity of these compounds to other species. 2-Phenylbenzothiazole, although highly toxic to mosquito larvae, failed completely against the house fly, silkworm, southern armyworm, and imported cabbage worm. On the other hand diphenylene oxide and diphenylene sulfide compared

TABLE 4. COMPARATIVE TESTS AGAINST MOSQUITO LARVAE OF THE MORE TOXIC ORGANIC COMPOUNDS CONTAINING SULFUR VS. ROTENONE. FIFTY LARVAE PER TEST

Name of compound	Concentration	Appearance of liquid in flasks	Time to kill 25 larvae Min.	Number dead in 8 hours	Number dead in 20 hours
Rotenone	1:100,000	Turbid	151	39	46
	1:200,000	Slightly turbid	272	34	47
Diphenylene sulfide	1:100,000	Very slightly turbid. Particles on bottom and surface and in suspension	59	50	—
	1:200,000	Clear. Particles on surface	62	50	—
2–Phenylbenzothiazole	1:100,000	Very slightly turbid. Particles on bottom and surface and in suspension	60	45	48
	1:200,000	Clear solution	213	31	35
p–Thiocresol	1:100,000	Clear solution	126	50	—
	1:200,000	Clear solution	214	45	49
β–Thionaphthol	1:100,000	Clear. Particles on bottom and surface and in suspension	228	42	46
	1:200,000	Clear solution	—	0	1
p–Bromthiophenol	1:100,000	Clear solution	386	33	42
	1:200,000	Clear solution	—	9	10
2–Phenyl–tetramethylene–1,3–disulfide	1:100,000	Clear solution	—	5	6
	1:200,000	Clear solution	—	1	3

TABLE 5. RELATIVE VALUE OF FOUR ORGANIC COMPOUNDS TESTED IN THE LABORATORY AGAINST FIVE SPECIES OF INSECTS

Species	Tested by	Application	Diphenylene oxide	Diphenylene sulfide	Carbazole	2-Phenyl-benzothiazole
Musca domestica	Campbell & Sullivan	Kerosene spray	Ineffective	Ineffective	———	Ineffective
Aphis rumicis	Campbell & Sullivan	Dispersed in water with K oleate, spray	Ineffective	Ineffective	———	———
Bombyx mori	J. W. Bulger*	Sandwich method	Effective	———	Effective	Ineffective
Prodenia eridania	M. C. Swingle*	Weighed dust deposit	Effective	Effective	Ineffective	Ineffective
Ascia rapae	M. C. Swingle*	Weighed dust deposit	Effective	Effective	Ineffective	Ineffective

*The writers are indebted to J. W. Bulger and M. C. Swingle for permission to mention their unpublished work.

favorably in toxicity with lead arsenate against the lepidopterous larvae, but failed in contact sprays. Carbazole was more toxic than lead arsenate against silkworm, but had no effect in practical dust deposits on the armyworm and cabbage worm and was unpromising against mosquito larvae. McAlister and Van Leeuwen[5] considered carbazole worth testing further against the codling moth.

Diphenylene oxide was effective in laboratory tests against several leaf-eating species when the insects were placed in Petri dishes on leaves dusted with this compound. When it was found later that spray deposits of diphenylene oxide volatilized and disappeared from bean leaves overnight, it seemed probable that it had been acting as a fumigant in the laboratory tests. Three much less volatile derivatives of diphenylene oxide; i. e., 2-chlorodiphenylene oxide, 2-amino-diphenylene oxide, and 2-nitrodiphenylene oxide, were then prepared. None was considered promising against the imported cabbage worm. The chloro and amino derivatives reduced feeding markedly, but none of the larvae died during the first 24 hours, and later mortality was low.

SUMMARY. Of 68 synthetic organic compounds, the majority of which were sulfur compounds, 24 were found to equal or exceed nicotine in effectiveness against culicine mosquito larvae. Diphenylene oxide and diphenylene sulfide were the most effective of these compounds, killing nearly 100 per cent of the larvae in 5 hours at 1:200,000.

In the course of the work two new compounds were prepared, p-hydroxyphenylacetimido-thiophenylether hydrochloride and phenylacetimido-thio-p-tolylether hydrochloride. The latter was probably the most toxic of the seven thioethers that were tested. It was effective against mosquito larvae at 1:100,000.

ADDENDUM. Since this paper was submitted for publication over a year ago, tests of organic sulfur compounds have been continued by J. W. Bulger and D. E. Fink against culicine mosquito larvae. The compound most toxic to these larvae (November 1934) is thiodiphenylamine (phenothiazine) which is more toxic than rotenone, being very effective at a concentration of 1:1,000,000. It was made by L. E. Smith, tested by Bulger, and retested by Fink.

[5]McAlister, L. C., Jr., and Van Leeuwen, E. R. 1930. Laboratory tests of miscellaneous chemicals against the codling moth. Jour. Econ. Ent. 23: 907–922.

CONTROL OF MEALY BUGS AND OTHER RESISTANT INSECTS ON HARDY PLANTS WITH A COMPLETELY REFINED PETROLEUM DISTILLATE*

By JOSEPH M. GINSBURG, Ph.D., *Biochemist in Entomology, New Jersey Agricultural Experiment Station*

Low boiling petroleum distillates were found to be very toxic to insects. Due to their high volatility and low surface tension, they readily penetrate living insects and eggs (1, 2). They also, however, readily penetrate plant tissue, resulting in varying degrees of injury, depending on the kind of plant. The application of petroleum oil sprays in this country began about 1881 when kerosene emulsion was first used to control San Jose scale. When applied pure, kerosene killed the scale but the tree as well. Since then we have learned that when petroleum distillates are highly refined, that is freed from unsaturated hydrocarbons, the injury is greatly reduced and on some plants, may be entirely eliminated (3, 4).

EXPERIMENTAL.—While studying the effects of paraffin waxes and various petroleum oil distillates on plants, the writer found that a completely refined, low boiling petroleum fraction was non-injurious to a large number of plants when lightly sprayed in pure unemulsified form, and showed high toxicity to insects. This product was furnished by L. Sonneborn Sons Inc. under the name of Deo-Base and possesses the following specifications:

A P I gravity	49–50
Flash point	170° F. open cup
Boiling range	370–490° F.
Unsulfonatable residue	98% or more
Odor	practically none
Viscosity	30 Saybolt at 100° F.

Preliminary results obtained with this oil suggested that it may prove of great value in controlling highly resistant insects such as mealy bugs and scale which usually require several successive applications of different contact insecticides. The writer was especially interested in the control of mealy bugs on greenhouse plants such as chrysanthemums and gardenias. Tests were, therefore, carried out on greenhouse plants infested with various insects. The purpose of these tests was two fold. First, to find out which of the greenhouse plants can be sprayed with the pure distillate without injury. Secondly, to obtain more information concerning the toxicity of this product to various insects. Several plants from each species were thoroughly sprayed and kept under observation.

*Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

Most of the plants which did not show injury from one spray application were sprayed again 8 days later. Out of some 34 different plants sprayed, 22 showed no injury whatsoever; 7 plants showed slight injury, and only 5 plants were severely injured. Insects encountered on these plants were thrips, mealy bugs, scale, aphis, red spider and white flies. In every case the kill was from 90 to 100%.

Plants showing no injury.—Aucuba, Aspidesperis, Begonia, Buddleia, Chrysanthemum, Cinerea, Coleus, Cyclamen, Easter Lily, Geranium, Juniper, Larkspur, Oleander, Pine (scrub), Pine (long leaf), Pine (white), Palm, Snapdragons, Stevia, and Rubber Plant.

Plants showing slight injury.—Fuchsia, Fern (Boston), Impatient Plant, Polygonum, Rose (rambler), Sweet Geranium, and Euphorbia.

Plants showing severe injury.—Calendula, Carnation, Poinsettia, Primrose and Rhododendron (young tips and buds).

The high per cent kill of mealy bugs was very encouraging and the man in charge of the greenhouse where the tests were carried out sprayed one entire bed of old chrysanthemum plants with pure Deo-Base. The plants were heavily infested with mealy bugs. No injury resulted to the plants and the entire bed remained practically free from mealy bugs for the rest of the season. Evidently no reinfestation occurred. This test was carried out in December 1932.

Tests on Mealy Bug Eggs.—Several chrysanthemum plants infested with mealy bug insects and egg masses were dipped in the pure distillate. Others were dipped in water to serve as check. On the check plants young nymphs began to appear 3 days after treatment. On the plants dipped in Deo-Base all the nymphs and adults were dead within 24 hours and no new nymphs appeared for two weeks, when the observations were discontinued. Under the microscope the eggs appeared shriveled and dry. The results from these tests show that this oil kills the mealy bug in all its stages, namely, egg, nymph and adult.

Encouraged by the above results, about 700 potted chrysanthemum plants infested with mealy bugs were dipped prior to transplanting to the beds. The process of dipping was as follows. The pot containing the plant was inverted and dipped into the oil to about one inch from the base of the stem, and momentarily withdrawn. The excess of oil was immediately shaken off. Such a procedure prevented the soil and roots from coming in contact with the oil. As far as the writer is aware practically 100% kill of the insect was obtained and no injury whatsoever resulted to the plants.

Another bed of some 500 young chrysanthemum plants infested with aphis and mealy bugs were sprayed three weeks after they had been

transplanted from the pots. The spraying was followed by several cloudy and rainy days. Observations made 24 hours later revealed complete kill of both aphis and mealy bugs. Five days after the spray application a large number of plants began to show yellowing of leaves, a distinct sign of injury. The source of this injury was later traced to the roots. The excess oil running off from the foliage was absorbed by the surface soil immediately surrounding the roots. Due to the prevailing high humidity, the rate of volatility was naturally low and the oil was gradually absorbed by the roots. Practically all of the plants, however, recovered from this injury, soon after dry sunny days returned, and are now showing normal growth. The results suggest that the oil should not be applied on cloudy days or when the relative humidity is high. These two experiments were carried out during July and August 1933.

The results thus far obtained suggest that "Deo-Base" or similar low boiling petroleum hydrocarbons can be applied on certain hardy greenhouse plants as a "clean-up" spray against insects which cannot be readily controlled with the ordinary insecticides. Due to the high wetting and spreading properties of this distillate, it requires a comparatively small amount to cover a plant, considerably less than water-spray mixtures. The sprayers should be adjusted with fine nozzles so that the spray is delivered on the plant in the form of a fine fog. Either dipping or spraying should be done on sunny days when the humidity is low. Buds or flowers, if present on the plant should not be sprayed, as permanent injury may result.

Tests with this distillate are continued with the purpose of ascertaining the minimum amount of oil required to kill insects without injuring plants when delivered from "fog" sprayers. A full report of the entire investigation will be published in due time.

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THE EELWORM *Rhabditis lambdiensis*, A NEW PEST OF MUSHROOMS

By LEONARD HASEMAN and H. O. EZELL

Perhaps the one most important limiting factor in the profitable growing of mushrooms is the destructive work of mushroom pests. Of the various pests, insects and their close allies are of greatest importance. From the nature of the crop and the conditions under which it is grown, only those pests which thrive in moist, dark and cool environments are able to thrive and seriously injure the crop.

In the early spring of 1931, a new pest of mushrooms appeared in one of the commercial mushroom houses at Leeds, Missouri. An eelworm, identified by Dr. G. Steiner of the Bureau of Plant Industry as *Rhabditis lambdiensis* (Maupas) was found associated with brown decay spots on the mushrooms. A month before the eelworms showed up, this house had a perfect stand and prospects for a record crop. After the eelworms and decay appeared, the production of mushrooms fell off and the beds were later abandoned. In the winter and spring of 1932, a second of the commercial houses at Leeds became infested and production was cut from 50 to 70%.

At first it was thought that the eelworms were the primary agent in causing the loss but Dr. G. Steiner,[1] who has made a careful study of the morphology and history of the species found balls of bacteria in the pharynx and the anterior portion of the intestine and he has concluded that the nema is probably only a carrier of the bacillus, which causes the decay of mushrooms, it feeding on the decomposed portion of the mushrooms caused by the bacillus. He points out that the disease seems to closely agree with one described by William Falconer in his treatise on mushroom culture published in 1910 and also supposed to be caused by nemas since they were found in all diseased spots. That disease, however, was later found to be bacterial in nature and caused by *Bacterium toloasi* (Paine).

Steiner states that *Rhabditis lambdiensis* has been found associated with different plant material, especially decaying plant materials, in various parts of the world. Experiments conducted by the Junior author indicates that it can feed and breed more or less indefinitely on a number of decaying materials. For several months, while their life cycle and breeding habits were being studied, cultures of these were kept breeding in the liquid filtered from decaying mushrooms.

[1]Steiner, G. Rhabiditis lambdiensis a Nematode Possibly Active as a Disease Agent in Mushroom Beds, Journ. Agri. Res. Vol. 4, No. 5, pp. 427–435, 1933.

LIFE HISTORY STUDIES.—In studying the life cycle of this nema it was observed that it gave birth to young, several at a time. In order to follow its development closely cultures containing a few nemas were kept in watch glasses for microscopic study. When they gave birth to young, the young in groups of twos were isolated and kept under constant observation. When fed on filter from decaying mushrooms at laboratory temperatures, the young matured and began to give birth to young in from two to four days. In most cases three days were required to mature. Under natural conditions where the food might be more concentrated they probably mature more rapidly. In some cases they reproduced young but once while in other cases in from two to five days they again gave birth to young. With conditions in a mushroom house favorable for rapid breeding and with the sprinkling of the beds helping to scatter them, they are soon able to overrun a mushroom house and spread the disease as they go.

The question was raised by the mushroom growers as to where the pest came from and how it got into the mushroom houses. From the general nature of the pest, its habits and its food supply, it was originally believed that it was taken into the cellars in the casing dirt and later experiments seemed to prove that this was true.

TEMPERATURE LETHAL TO *Rhabditis lambdiensis*.—A series of experiments were made to determine the killing temperature for the pest in order to find out if it was possible for it to withstand the temperature which usually is obtained in the composting of the manure on which the mushrooms are grown. Cultures of the nematodes were placed in vials and these were placed in a constant temperature chamber. A thermometer introduced through the side of the chamber was fitted into the mouth of the vial so that the bulb of the thermometer rested in the liquid in which the nematodes were feeding. The temperatures of the chamber could be regulated at will and by using the thermometer inserted in the culture, it was possible to determine accurately the temperature of the media in which the nematodes were feeding. Temperatures varying from 30° C. to 45° C. with exposures of 30 minutes were tested. Temperatures up to 38° C. had no ill effects on the nematodes. Temperatures from 39° C. to 41.2° C. killed some but some revived. Temperatures from 42° C. (107.6° F.) to 45° C. (113° F.) killed all the nematodes. Gahm's[2] investigations indicate that except for the first few inches on the sides of a pile of compost the temperature stands higher than the lethal temper-

[2]Gahm, O. E. The mite Linnopodes antennae, (Banks) as a pest of cultivated mushrooms, with preliminary tests toward control. Journ. Eco. Ento. XXIII, No. 4, 744, 1930.

ature for this nematode. Considering the minute size of the nematode and its inability to travel rapidly, it seems evident that in turning the compost piles there would be no possible means of this pest escaping the high temperature which obtains in the pile. If the pest is not taken into the house with the compost it must be taken in with the casing dirt.

TREATING THE CASING DIRT TO DESTROY THE NEMATODES.—Laboratory tests were made to determine the possibility of fumigating the casing dirt with carbon bisulphide to kill the nematodes. Practical tests also were made in one of the commercial mushroom houses at Leeds to determine the possibility of preventing the introduction of the pest with the casing dirt by first treating with carbon bisulphide. The growers heated the casing dirt to 70° F. and then treated it with one pound carbon bisulphide per 100 cubic feet of dirt. Beds on which this dirt was used later showed no signs of nematodes though the grower had nematodes in some of his beds at the time. Later he used 10 pounds to 100 cubic feet of soil without first raising its temperature and likewise had no trouble with nematodes. Laboratory tests to determine the lethal dosage of carbon bisulphide, were conducted, using glass cylinders of known capacity to enclose the soil and the nematodes. Nematodes feeding on decomposed mushrooms and bits of apple were placed in glass vials the mouths of which were covered with cheese cloth. These were placed 4 inches below the surface of the soil in the cylinders. Doses of from one to eight pounds of carbon bisulphide per 100 cubic feet of soil were used with exposures of 2½ hours and with the temperature of the soil at 75° F. to 77° F. Doses of from 1 to 1½ pounds failed to kill the nematodes. Doses of from 2½ to 3 pounds killed most of them and doses from 4 to 8 pounds killed all of them. Repeated tests of 4 pounds for 2½ hours at a temperature of 77° F. gave complete kill of the nematodes as well as of the mites and spring tails. From the fact that the nematode feeds and breeds normally in the laboratory on decomposing mushrooms, apples, potatoes, cabbage, tomatoes, bananas and carrots, it would be perfectly simple for the grower to introduce it into his mushroom house with the casing dirt, which is usually a good grade of garden soil. If the pest is taken in only with the casing dirt, it should be a simple matter to treat this and prevent the pest from becoming established in the mushroom beds.

NICOTINE VAPOR IN CODLING MOTH CONTROL[1]

By RALPH H. SMITH, HENRY U. MEYER and CHARLES O. PERSING, *University of California Citrus Experiment Station, Riverside, Calif.*

During the summer of 1928 the senior author carried on a series of orchard experiments designed to effect the control of the codling moth by killing the moths of the spring brood at intervals of two or three days throughout their period of emergence, or to supplement the control obtained with spraying by killing the moths at the peak of emergence of the different broods, using nicotine as the insecticidal agent.[2] A nicotine product having a content of 95 per cent nicotine alkaloid was dissolved in kerosene, gasoline, and petroleum ether by means of butyl alcohol as an intermediate solvent, and these solutions were atomized through the trees. The solutions were atomized by specially constructed devices placed in the trees and also by means of a paint gun equipped with an FF 22 De Vilbiss nozzle.

The effectiveness of the treatment was determined by placing cages containing moths in various parts of the trees and by covering the ground below the trees with muslin sheets 24 feet square to catch the moths that fell from the trees. The results showed that the moths were killed where it was possible to envelop the trees with a fog of the finely atomized solution for a period of from 1 to 3 minutes, depending on the concentration of nicotine in the solution. However, because of the difficulty involved in treating uniformly all parts of the tree and because of the high dosage required to kill all the moths, the method was regarded economically impractical. The same experience was had in using pyrethrins dissolved in kerosene.

HIGH TOXICITY OF NICOTINE VAPOR DETERMINED.—During the past summer a project was undertaken with the object of investigating the possibility of using hydrocyanic acid in killing the codling moth. The scheme provided for covering the trees with light weight fumigating tents like those lately used in fumigating avocado trees. The dosage required to kill the moths (more than 30 cc of liquid HCN to 1,000 cu. ft., with an exposure of 10 minutes) was found to be so high that this method of control also proved to be economically impractical. Upon the suggestion of the junior author, Mr. Persing, a test was made with nicotine sulfate vaporized by heat, and this led to the discovery that 1 cc of "Black Leaf 50" when vaporized was more effective in killing the moths than was 30 cc of liquid HCN.

[1]Paper No. 306, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

[2]The investigation was supported in part by a grant of money provided by the Tobacco By-Products and Chemical Corporation. A. W. Lopez, Ben. J. McElroy, and J. P. La Due assisted with the work.

The high degree of toxicity of nicotine vapor was demonstrated by various preliminary experiments. Moths subjected for only 2 or 3 seconds to a blast of concentrated vapor developed paralysis and died. Screen cages containing moths were placed at distances of 6, 12, and 18 feet in front of a 14-inch electric fan outdoors and 1 cc of "Black Leaf 50" was vaporized in a casserole placed immediately in front of the fan. The moths 6 feet away were killed, those 12 feet away were badly paralyzed but apparently fully recovered after several hours, and those 18 feet away showed a small degree of paralysis. An apple tree 22 feet high and 24 feet in spread (approximately 4,500 cubic feet in volume), throughout which were suspended cages containing moths, was covered with a fumigating tent and 6 cc of "Black Leaf 50" was vaporized under the tent. All moths were killed.

THE NICOFUMER, A NEW DEVICE FOR UTILIZING NICOTINE AS AN INSECTICIDE.—A device which we have designated a Nicofumer was designed and built with the object of providing a practical means of utilizing nicotine in the form of a vapor or a vapor-like mist in the control of insect pests. The essential features of the device and its operation are described as follows: The nicotine or nicotine sulfate is contained in a chamber connected through a pressure regulator with a compressed air tank. Tubes arranged to produce atomization lead from the chamber and discharge into two copper pipes, each 2 inches in diameter and 30 inches in length. The pipes are inclosed in a shield and are heated to approximately 350° C by means of a gas burner extending lengthwise below them. The gas is contained in a pressure tank. The pipes extend into the intake of the blower of a standard type power duster used in insect control work. In passing through the pipes, the finely atomized nicotine changes to dense fumes which are carried through the blower to the vegetation. Baffles made of screen are placed in the pipes in order to facilitate the vaporization of the nicotine. The rate at which the nicotine is fed through the atomizer is governed by the pressure regulator. The nicofumer is shown in Figure 143.

Very good results have been obtained by conveying the finely atomized nicotine to the blower without completely vaporizing it. Tests made with nebulizers and atomizers producing extremely fine particles indicate that nicotine applied in this form may be more potent as an insecticide than where applied as a spray or dust.

PORTABLE FUMATORIUM.—The effectiveness of the treatment depends upon the concentration of the vapor in the atmosphere surrounding the insect and upon the length of time the insect is subjected to the vapor. Since the maximum degree of effectiveness may be obtained by dis-

FIG. 143.—Nicofumer, a device for utilizing nicotine in the form of vapor or finely atomized mist in the control of insect pests.

charging the vapor under a cover dragged over the crop to be treated, our experiments have been mostly along this line of endeavor. For the treatment of apple trees we have built and tested with a fair degree of satisfaction a portable fumatorium, shown in Figure 144, by means of which trees as large as 26 feet in height and 26 feet in spread may be enclosed and treated at the rate of one tree each half minute. This device consists of a single upright support bearing a transverse boom which extends over two rows of trees and is adjustable to trees of different

FIG. 144.—Portable fumatorium used in experiments on the control of the codling moth with nicotine vapor.

sizes. The boom supports a large canvas cover and two curtains which permit enclosing the trees quickly and completely. The entire device is mounted on an automobile truck. Its use would be impractical in many orchards where the trees are closely planted and grown together. It affords the important advantage of concentrating the vapor, sheltering the trees, and permitting effective treatment under atmospheric conditions which would make open-air treatment impossible.

PRACTICABILITY, EFFECTIVENESS, AND COST.—The results obtained in orchard tests are considered sufficiently encouraging to warrant believing that the method may possess considerable merit. The results of treatments made with the portable fumatorium indicate that all the moths in trees 24 ft. in height and 24 ft. in spread can be killed with a dosage of 10 cc of "Black Leaf 50" per tree, where the rate of treatment is one tree per minute. On the basis of the present retail price of $1.26 per pound, the cost of 10 cc is $0.02838. The cost of labor, based on the use of 4 men at a total wage of $1.60 per hour, and on the treatment of one tree per minute, would amount to $0.02666 per tree. Depreciation on equipment is estimated at $0.0075 per tree. The cost per acre, figuring 60 trees to the acre, would be as follows:

Number of treatments	Material	Labor	Depreciation	Total
1	$ 1.70	$ 1.60	$ .45	$ 3.75
10	17.02	15.96	4.50	37.48
15	25.53	23.94	6.75	56.22
20	34.04	31.92	9.00	74.96

Data recently obtained in the western states indicate that the total loss chargeable to the codling moth, including cost of spraying, loss from worms despite spraying, and costs attendant upon spray residue removal, ranges from $75.00 to $130.00 an acre.

The use of nicotine vapor is postulated on the idea that it also will control leaf roller, aphids, and other insect pests. There is a possibility that the destruction of the moths once at the peak of emergence of each brood may greatly simplify the problem of control by spraying. The treatment of a part of a grove at the peak of the second brood the past season apparently gave very good results. With this plan it is possible that the moths can be killed by applying the vapor at night or whenever the atmosphere is calm, without using the fumatorium, using perhaps 30 cc of "Black Leaf 50" per tree, at a cost of $5.50 per acre for material and labor.

It is hoped that practical orchard tests may be made during the year 1935, which will determine the merit of using nicotine vapor in codling moth control and also provide data on the value of nicotine vapor compared with nicotine spray and dust in the control of insects in general.

Scientific Notes

The Box Elder Bug in New York. *Leptocoris trivittatus* Say, so common in the middle west but heretofore unobserved in New York, seems to have established itself here. On Oct. 6, 1934, I received living specimens from Cobbleskill and on Nov. 9 collected the insects in Penn Yan. In both cases they infested ornamental box elder trees. Specimens were also received from Watertown. C. R. CROSBY, *Ithaca, N. Y.*

The Sex Ratio of *Macrocentrus ancylivorus* Roh. One of the problems in the mass production of beneficial insect parasites is the maintenance of a favorable sex ratio. Many species when reared under confinement tend toward the production of an abnormal proportion of males. In such instances it is helpful to know the normal sex ratio, so that under varied conditions of breeding any departure from the normal can be detected, and steps taken to correct unfavorable trends whenever they occur.

The following information has been obtained on the sex ratio of *Macrocentrus ancylivorus* Roh., an important parasite of the oriental fruit moth. It has been obtained from adult parasites emerging from approximately one half million larvae of the strawberry leaf roller (*Ancylis comptana* Froehl.) collected in Burlington County, New Jersey, from 1931 to 1934, inclusive. Since these data are based on a large number of individuals, reared from material collected from the field only a few days previous to parasite emergence, the sex ratio observed should be very nearly normal. Data of parasite emergence are tabulated below. It is to be noted that the average for the four years is approximately 6 females to 4 males, and that the greatest departure of any year from the average is only 1.55 per cent.

Year	Total emergence both sexes	Number of females	Number of males	Per cent of females	Per cent of males
1931.....	25,293	15,304	9,989	60.51	39.49
1932.....	39,407	22,916	16,491	58.15	41.85
1933.....	14,980	8,479	6,501	56.60	43.40
1934.....	40,685	23,290	17,395	57.24	42.76
Total for 4 years....	120,365	69,989	50,376	58.15	41.85

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Birds as Predators of the Beet Leafhopper. During the fall of 1934, small birds in various sized flocks were observed to be feeding among Russian thistle and *Bassia hyssopifolia*, in northern Utah (Tooele County) desert breeding grounds of the beet leafhopper, *Eutettix tenellus* (Baker). This report is based on approximately 150 bird specimens which were collected during September, among, or in the vicinity of, host plants of the beet leafhopper. Gizzards of 12 of the 20 bird species collected contained *E. tenellus*. Birds whose gizzards contained identifiable *tenellus* were: Rock wren, *Salpinctes obsoletus obsoletus* (Say), 4 *tenellus;* ruby-crowned kinglet, *Corthylio calendula cinerascens* (Grinnell), 3; Audubon warbler, *Dendroica auduboni auduboni* (K. T. Townsend), 19; pileolated warbler, *Wilsonia pusilla pileolata* (Pallas), 67; western grasshopper sparrow, *Ammodramus savannarum bimaculatus* Swainson, 26; western vesper sparrow, *Pooecetes gramineus confinis* Baird, 6; Shufeldt junco, *Junco oreganus shufeldti* Coale, 13; western tree sparrow, *Spizella monticola ochracea* Brewster, 2; western chipping sparrow, *S. passerina arizonae* Coues, 382; white-crowned sparrow, *Zonotrichia leucophrys* (J. R. Forster), 53; and Lincoln sparrow, *Melospiza lincolni lincolni* (Audubon), 29. A white-rumped shrike, *Lanius ludovi-*

cianus excubitorides Swainson, contained a brown-shouldered *Uta* lizard, *Uta stansburiana stansburiana* (B. and G.), together with 3 *tenellus* and other insects. As the lizard had been torn in two, it is possible that the *tenellus* came from the torn lizard stomach, rather than being taken directly by the bird.

It appears that migrating, as well as native, insectivorous birds will readily feed upon the beet leafhopper when this insect is present in abundance, as is usually the case on northern Utah breeding grounds during September and early October. Upon the departure of the hunters, these birds soon returned to the Russian thistle and *Bassia* breeding areas and in several cases returned in spite of the presence of hunters, provided the men remained quiet among rocks or near the car used by the hunting party.

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Sitotroga Production. During a period of over one and one-half years an egg production estimated to exceed 50,000,000 was obtained from moths reared from 1,400 pounds of corn. The "tilted bin" type of production unit, described in the Journal on page 1008 of Vol. 23, and page 510 of Vol. 26, was used. Collections began in March, 1933. The maximum daily production was obtained during July and August of the same year.

When a comparatively small but continuous supply of *Sitotroga* eggs are needed, corn is recommended for the moth rearing medium, because the amount of equipment manipulation is much less than when wheat is used.

Wheat is used generally in laboratories producing *Sitotroga* eggs for seasonal field work, since the total production per unit weight of grain is reached much more rapidly with wheat than with corn.

A kernel of grain, irrespective of its size, is usually inhabited by only one Sitotroga larva at a time. This is apparently due to the internecine activity of the newly hatched larvae. Under mass production conditions the number of moth eggs on the grain probably greatly exceeds the number of kernels. Apparently in the case of *Sitotroga*, if given equal weights of wheat and of corn, the rapidity with which the grain is utilized varies inversely with the size of the kernels. Since the wheat kernel is much smaller than that of corn, it follows that wheat is completely utilized in a shorter period than is the corn.

The use of wheat entails frequent replacement and the consequent increased amount of handling affords greater opportunity for the establishment of *Pediculoides*.

Plodia interpunctella became established in the production unit soon after production started. *Microbracon hebetor* was then introduced and effectively kept *Plodia* in check.

S. E. FLANDERS, *University of California Citrus Experiment Station, Riverside, California*

An Unusual Outbreak of Stable Fly and Its Control. An unusually severe outbreak of stable fly (*Stomoxys calcitrans* Linnaeus) occurred in the vicinity of Greenville, South Carolina, sewage disposal plant. The area infested extended for two or three miles from the disposal plant. In the infested area were numerous dairies, homes and a relatively small amount of farm land. Reports from farmers and householders living in the area indicate that the infestation had become increasingly greater since the construction of the plant about four years ago.

When the writer first visited the area on July 23, it was found that the stable fly infestation was so great that farmers were forced to cover mules in cultivating cotton. Milk production in dairies was off 50 per cent and residents were on the verge of leaving their homes. A survey disclosed the fact that flies were breeding in manure heaps and straw piles, but that the conditions for breeding were not greater than on less severely infested farms in the county. A continuation of the survey disclosed the fact that numerous flies were breeding on the trickling filters of the sewage disposal plant. These flies were subsequently reared and submitted to Dr. F. C. Bishopp of the U. S. Bureau of Entomology and Plant Quarantine, who confirmed the writer's determination of the species.

A new situation in the breeding of stable flies was therefore discovered. A thorough search of literature failed to disclose any reference to the breeding of stable fly on the trickling filters of sewage disposal plants. A survey made by the engineer constructing the disposal plant over thirteen Southern States failed to reveal another stable fly infestation.

Control measures for the fly had to be worked out on the scene with the cooperation of city officials. Chemicals were barred because of their possible influence on the nitrifying bacteria on the trickling filters. Screening the trickling filters would have undoubtedly solved the problem, but the cost was excessive. It so happened that the plant was constructed so that the trickling filters could be flooded with water. The first flooding disclosed the fact that many pupae could be floated to the surface where they could be skimmed off. At this time it was thought that submergence of pupae for a period of 24 hours would prevent emergence of flies, but an emergence of 80 per cent occurred when pupae were flooded for a period of 24 hours. In the meantime the idea of drowning the maggots occurred to the writer, who communicated with Dr. Bishopp. After the water stood on the maggots for a period of 24 hours they were drowned and washed away, leaving only pupae on the trickling filters to emerge as flies. Later, on the advice of Dr. F. C. Bishopp the time of submergence was reduced to 12 hours. The trickling filters were submerged twice each week. Within a month it was impossible to find flies breeding on the filters and the number of flies on adjoining farms had been reduced to the point where they were not troublesome.

This situation has brought forth two important points in connection with the biology and control of stable flies; namely, (1) the stable fly is able to breed on the trickling filters of sewage disposal plants; and, (2) the flies may be controlled by submerging with water without destroying the effectiveness of the bacteria.

W. C. NETTLES, *Clemson College, S. C.*

Dolichopodidae in a Greenhouse. During the latter part of November, I found a species of *Dolichopus* in great abundance in a greenhouse in Boulder; it has been kindly identified for me by Mr. M. C. Van Duzee as *D. ramifer* Loew. It is very widely distributed in North America, from east to west; Mr. Van Duzee has taken it many times in California. I was not able to ascertain whether these flies were in any way injurious, or perhaps useful as destroyers of small, harmful, insects. Could they, for instance, feed on thrips? Probably the matter deserves investigation.

T. D. A. COCKERELL, *Boulder, Colorado*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER, 1934

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings, 1934-1935, Pittsburg; December 1935, St. Louis; Summer meetings, 1934, Berkeley, June 18-23; 1935, Minneapolis.

The voluminous and scattered nature of American economic entomology is demonstrated in the recently published: "An Annotated Bibliography of the Hessian Fly" by Dr. Wade. This is a miscellaneous (U. S. D. A.) publication of 100 pages. It cites 1,256 references, covers a period of nearly 150 years and is the result of 18 years of collection by the compiler. The authors are listed alphabetically. The chronological index facilitates looking up the record for any particular period and just a scanning of that gives an excellent idea of the years when this ancient pest of grain fields was injurious, since there is a fairly close correlation between the amount of injury and the number of references. One must congratulate the compiler upon his patience and also conclude that the enormous work embodied in this modest publication is justified by the facility with which subsequent students may acquaint themselves with the previous history of this important pest.

The Department of Entomology at Cornell University has recently moved into a new building, formerly the Home Economics Building, and now rededicated as Comstock Hall, a most fitting memorial to a teacher whose work has influenced entomological activities throughout the world and whose disciples, both at home and abroad, are worthily upholding the ideals he formulated. The growth of the entomological department is suggested by the floor areas occupied in the successive periods. In 1872 there were 307 square feet, which were increased in 1881 to 2900 square

feet, and in 1906 to some 12,000 square feet. The latest change places at the disposal of this Department some 30,000 square feet, with definitely assigned quarters for the different phases of entomological work on the five floors. The present output, if it may be termed such, is indicated by the fact that in the last college year, namely 1933–1934, there were 56 graduate students majoring in Entomology as candidates for Master's or Doctor's degrees. This is a striking record epitomizing the development of entomological work in America which has occurred not only at Cornell University, but in many other institutions in this country. It is presumable that the development outlined above is but a step in further expansion, as the cultural and economic possibilities of a knowledge of insects and their ways become more generally appreciated.

Review

Veterinary Helminthology and Entomology, The Diseases of Domesticated Animals caused by Helminth and Arthropod Parasites by H. O. MONNIG, pages i–xvi, 1–402, 264 text illustrations, William Wood & Company, Baltimore, 1934.

This important volume is primarily of interest to the veterinarian, though the entomologist concerned with the insects, parasitic or otherwise, of animals will find much of value in the somewhat extended discussions of the various species. The purpose of the volume is practical rather than taxonomic and morphological. There is a general section on parasitism in its various aspects, a second on technique, which is followed by a third section dealing with the various forms in their natural groups, the Trematodes, Cestodes, with minor classes preceding the nearly 80 pages devoted to the Insecta, there being in this portion somewhat full accounts of the more important species. The text in relation to the insects includes brief characterizations of the orders and a general discussion of the more important structures of representative forms. There is also an excellent treatment of the more important parasitic mites, such as the ticks, Ixodoidea, the scab mites, Sarcoptoidea, also the poultry mites, the harvest mites, the grain itch mite and the parasite mites belonging in the genus Demodex. There is a comprehensive host-parasite list and an excellent general index.

The general entomologist will find this volume a very convenient reference work when searching for information in relation to insects and other forms occurring upon most of our domestic and a number of wild animals, something of value, since we are coming to learn more and more that entomology is not concerned solely with insects, but that these latter are only a part of a general environment.

E. P. FELT

Current Notes

Charles H. Balloy is professor of entomology and pomology, Escuela Nacional de Agricultura, and chief of the corresponding sections, Centro Nacional de Agricultura His address is Apartado 1368, San Jose, Costa Rica., as reported in a recent issue of Cornell Alumni News.

The eleventh annual conference of entomologists working in Connecticut was held in Room 429, Beach Building, at the Connecticut State College, Storrs, on Friday, October 26, 1934. Dr. R. B. Friend was elected chairman and 74 were present. A cafeteria luncheon was served in the College dining hall. Professor Crandall and Mr. Worthley were unable to be present but both submitted papers. Professor Crandall's paper was read by Professor J. A. Manter, and Mr. Worthley's paper was read by H. N. Bartley. It was the opinion of several present that this was one of the most interesting and successful of all the meetings held.

The following program was carried out:

PROGRAM

Greeting.....President Charles C. McCracken, Storrs
Some Recent Investigations of the Honey Bee .....Prof. L. B. Crandall, Storrs
Entomological Features of the Season of 1934.....Dr. W. E. Britton, New Haven
Present Status of Salt Marsh Mosquito Ditching in Connecticut
R. C. Botsford, New Haven
Status of the Japanese Beetle in the United States..L. H. Worthley, Harrisburg, Pa.
Gipsy Moth Conditions in 1934.....A. F. Burgess, Greenfield, Mass.
Effect of Weevil Injury on White Pine.....Dr. R. B. Friend, New Haven
Contributions of Entomology to Sociology.....Dr. J. L. Hypes, Storrs
Entomological Work in the Orient (Motion picture)
Charles A. Clark, Melrose Highlands, Mass.
The Hickory Horned Devil (Motion picture).....Prof. J. A. Manter, Storrs
Luncheon
The Dutch Elm Disease Menace to Our Elm Trees.....Dr. E. P. Felt, Stamford
Notes on Insects Concerned with Dutch Elm Disease Studies in Connecticut
Dr. B. J. Kaston, New Haven
General Status of the Oriental Fruit Moth in Connecticut
Dr. Philip Garman, New Haven
Breeding and Distribution of *Perisierola angulata*, an Australian Parasite of the Oriental Fruit Moth.....J. C. Schread, New Haven
Mass Production of *Macrocentrus ancylivorus*.....W. T. Brigham, New Haven
Apparatus for Dusting Sulfur on Plants in Controlled Amounts, and Method of Testing for Minute Quantities.....M. V. Anthony, New Haven
Toxicity of Pure Nicotine and Pure Anabasine for *Aphis rumicis*,
Dr. Philip Garman, New Haven
European Corn Borer:
The European Corn Borer as a Pest of Dahlias.Dr. C. H. Batchelder, New Haven
The Problem of Weed Infestation in Connecticut.....Neely Turner, New Haven
Enforcing the Compulsory Clean-up in Connecticut in 1934
M. P. Zappe, New Haven
Damage to Early Sweet Corn in Connecticut in 1934.J. P. Johnson, New Haven

The eleventh annual meeting of the Rocky Mountain Conference of Entomologists was held in the Colorado Agricultural College Forestry Lodge, Pingree Park, Colorado, August 12 to 17 inclusive. A total of 11 sessions were held for papers, discussions and business. The following are the topics listed in the program altho many others came up in the informal discussions that formed an important part of the meeting.

Grasshopper Symposium.—Leaders, C. J. Drake, E. G. Kelly and Kenneth Shanks.

Notes on the Black Widow Spider, *Lactrodectus mactans* Fab.—Albert Milzer.

Aphids and the Evolution Theory.—C. P. Gillette.

A List of the Hemerobiidae of Pingree Park.—Roger C. Smith.

The Iowa Chinch Bug Outbreak.—C. J. Drake.

Further Observations on Factors Influencing Codling Moth Bait and Light Trap Attrahency.—John R. Eyer.

Nineteen thirty-four and nineteen thirty-five Codling Moth Observations.—J. H Newton.

The Robber Flies of Oklahoma.—A. E. Prichard.

Notes on the Cotton Boll Weevil.—Ephriam Hixson.

China as She Appears to a Zoologist.—Wm. A. Riley.

The Fossil Beds at Florissant, Colorado.—F. Martin Brown.

Random Notes on Chloropidae.—Curtis W. Sabrosky.

Methods of Apiary Inspection.—R. G. Richmond.

An Outbreak of Midges—F. E. Whitehead.

Aphid Classification for General Entomologists and Laymen.—M. A. Palmer.

Recent Developments in the Study of Alfalfa Insects in Kansas.—Roger C. Smith.

The Reproductive System of Grasshoppers.—Mary T. Harman.

Aquatic Insects as Hosts of Helminths Affecting Vetebrates.—Wm. A. Riley.

Notes on the Revision of Odontomyia.—M. T. James.

Further Observations on the Pathological Histology and Phytochemistry of Psyllid Yellows.—John R. Eyer.

The Yampa Canon of Colorado.—F. Martin Brown.

The Habits of *Lithurgus apicalis* Cress.—Charles H. Hicks.

Motion Picture Films Entitled "The Swallow Tail Butterfly"—"The Bumble Bee," "Natures Handiwork" and slides on "Colorado Wild Flowers," and "Fossil Insects from Florissant, Colo.," furnished by Mrs. T. D. A. Cockerell were shown by Mrs. M. T. James.

We were favored with good roads, excellent weather, good collecting and fishing, a congenial crowd and hot weather "at home" to make people appreciate the mountain air.

A mimeographed report, giving abstracts of the talks, will be available soon to those that were present and others that may request it.

The officers elected for 1935 were C. P. Gillette, Chairman; C. L. Fluke, Vice-Chairman; Geo. M. List, Secretary and C. R. Jones, Treasurer.

GEORGE M. LIST, *Secretary*

Horticultural Inspection Notes

The Oregon quarantine relating to the strawberry root weevil was revoked on October 31 as "no longer necessary." This quarantine had been issued on June 6, 1927, on account of the existence of the weevil "over an indeterminable area of Oregon."

Frank A. Soraci, a graduate of the New York State College of Forestry, Syracuse, New York, and formerly with the United States Forest Service at Glidden, Wisconsin, is now with the Bureau of Plant Industry of the New Jersey Department of Agriculture.

B. M. Gaddis of the Bureau of Entomology and Plant Quarantine during the first half of October visited the States of Georgia, Louisiana, and Texas, to consult with Federal and State officials relative to phony peach disease and citrus canker activities in those States.

In June, W. H. Rankin was appointed Supervisor, Control of Dutch Elm Disease, to direct Dutch elm disease eradication and control work in New York State. L. A. Gilbert, one of the New York inspectors, was transferred to work under him as inspector for Dutch elm disease.

The European corn borer is now known to be generally established in Accomac and Northampton Counties, Virginia, from the Maryland line south to Cheriton, according to a recent announcement by Mr. G. T. French, State Entomologist. An intrastate quarantine was placed October 4 to prevent the transportation of the insect on the ferries across to the mainland where, Mr. French states, extensive surveys have failed to locate it. The restricted articles may be moved under a State or Federal certificate.

Under the Oregon quarantine relating to gladiolus thrips, which was reissued October 25, gladiolus corms or parts of the plants may not be transported from one point to another in the State at any time of the year unless they are treated under an approved formula and the storage house fumigated. Five methods of treatment are approved by the State Department of Agriculture. Corms coming into the State are also required to be so treated at destination unless certified in advance as having been treated with a formula approved by the United States Department of Agriculture

B. D. Van Buren, Director of the Plant Industry Bureau, Department of Agriculture and Markets, of the State of New York, retired on November 30, after having served in the Bureau a total of approximately thirty-three and one-half years. Mr. Van Buren first went to work for the Department as nursery inspector in the field under an appointment dated May 2, 1901. In 1910 he was appointed Assistant Director of the Plant Industry Bureau, and upon Dr. Atwood's retirement in 1927, succeeded him as Director of that Bureau.

The Missouri State Department of Agriculture reports that 1,351 Japanese beetles were caught in the city of St. Louis in beetle traps during the past season. Two areas in the city were accordingly placed under intrastate quarantine effective October 15, and 250 tons of lead arsenate, it is stated, are being applied to the soil in and adjacent to the regulated areas at the rate of 1,000 pounds per acre. No nurseries or greenhouses of any size are within these areas. The work is carried on cooperatively by the Missouri State Department of Agriculture, the Missouri Relief and Reconstruction Commission, the city of St. Louis, and the United States Department of Agriculture.

The alfalfa weevil quarantines of Kansas and Illinois were recently reissued to bring additional territory under regulation, and in the case of Kansas, to eliminate the requirement of winter milling of alfalfa meal as a condition of certification. Uniformity of action under the two quarantines was taken in designating as infested 9 counties in Colorado, all of Idaho lying south and southeast of Idaho County, 5 counties in Oregon, the entire State of Utah, and 13 counties in Wyoming. The Kansas quarantine, however, lists 12 counties in California as infested, while the Illinois quarantine lists but 10; and the Kansas quarantine applies to the entire State of Nevada, while the Illinois quarantine applies to all Nevada counties save one.

On October 15, S. B. Fracker was designated leader of the Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, to succeed the late Dr. Karl F. Kellerman. Bevy M. Gaddis was placed in charge of the Division of Domestic Plant Quarantines. Mr. Gaddis first became associated with the plant quarantine work of the Department in connection with the eradication of the Mediterranean fruit fly in Florida. Later he was connected with the work on the eradication of the Mexican fruit fly conducted by the Department in Texas, and since last March had charge of the Minneapolis headquarters for activities of the Department in connection with the control of grasshoppers and chinch bugs.

Under Amendment No. 2 to the Pink Bollworm Quarantine Regulations, effective October 31, 1934, the area under regulation was increased by adding Dixie, Hamilton, Lafayette, Levy, and Taylor Counties in Florida, as well as Andrews, Ector, and part of Midland County, Texas. The Florida counties were brought under regulation because of the finding of a light infestation of pink bollworm in Hamilton and Levy Counties. Lafayette, Taylor, and Dixie Counties have no ginning facilities, so farmers in these counties have their cotton ginned in the nearby counties where infestation has been found. The counties in Texas were added as a result of the discovery of a few pink bollworms in part of Midland County, as well as in Ector and Andrews Counties.

Mr. Ernest Wright, Plant Pathologist of the Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, whose headquarters are in San Francisco, Calif., called at the office of the Nebraska Department of Agriculture, on October 20th for a conference in regard to the control of plant diseases in nursery stock to be used in the proposed Shelterbelt that is to be planted across the western part of Nebraska and nearby States. The office of the Plains Shelterbelt Project of the Forest Service, which is located at Lincoln, Nebraska, plans to cooperate with the State Department of Agriculture in arranging for the inspection and certification of all nursery stock that is to be grown in Nebraska for planting in the Shelterbelt.

The gypsy moth quarantine regulations were revised effective October 2. The revision reduces the size of the regulated area in Vermont, and designates as generally infested certain territory of Connecticut, Maine, New Hampshire, and Vermont which has heretofore been classed as lightly infested. It also modifies the boundaries of the area designated as brown-tail moth infested in the States of Maine, Massachusetts, and New Hampshire, and adds parts of four counties in Vermont. Additional changes include the exemption of such woody plants as have been grown in the greenhouse throughout the year and are so labeled; the authorization of the shipment of Christmas trees from the generally infested area when grown as nursery stock in a cultivated nursery and certified under the nursery stock provisions; the adding of empty cable reels to the list of restricted articles; and slight modifications in the procedure for the certification of car-lot shipments.

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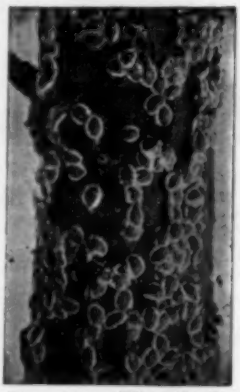

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